Williston Reservoir Raising

Environmental Overview

B.C. Hydro
Environmental Services
System Operations and Maintenance Division

Report No. ES-118

June 1987
Revised July 1988

B. C. HYDRO

WILLISTON RESERVOIR RAISING

ENVIRONMENTAL OVERVIEW

ENVIRONMENTAL SERVICES
SYSTEM OPERATIONS AND MAINTENANCE DIVISION

June 1987

Revised July 1988

IR79.1

Report No. ES-118

PREAMBLE

This environmental overview report was prepared by B. C. Hydro as an initial assessment of the possible 1.5 m (5 ft) raising of the Williston Reservoir maximum normal level. The environmental overview study and the associated engineering and property studies were undertaken in order to provide information for a decision on whether to initiate more detailed studies of the proposal.

In general, overview studies are the first stage of B. C. Hydro's project investigations process. These studies are based mainly on available reports, mapping and field data, supplemented by limited site reconnaissance and, in this instance, input from key agencies and groups.

In the Williston raising overview study it turned out that the lack of adequate mapping of areas which could be affected by reservoir raising did not permit definitive conclusions about the project to be reached. It became apparent that such mapping would have to be done in order to complete the overview assessment and it is planned to do this mapping over the next year.

The environmental overview report was originally prepared in June 1987 and was revised in July 1988. Further revisions may be necessary after the new photogrametric information has been analyzed.

Despite the shortcomings of the available mapping, a considerable body of inventory information is contained in the environmental overview report. As this information may be useful to others, B. C. Hydro is issuing the environmental overview report on a preliminary basis now rather than await completion of the aerial photography program. Advance release of the environmental report is intended to signify B. C. Hydro's appreciation for the assistance provided to the study team by government agencies, forestry companies and others.

Because of study limitations B. C. Hydro accepts no responsibility for the accuracy or completeness of the data and other information contained in the report. For example the reservoir clearing standards presented in the report were selected only for the purpose of preparing preliminary cost estimates for the project and do not imply any commitment or preference by B. C. Hydro at this stage for a specific clearing standard. We also emphasize that there is no decision by B. C. Hydro at the present time on whether to undertake more detailed studies of the project beyond the recommendation to obtain updated aerial photography.

Anyone having questions concerning this report should contact B. C. Hydro, Corporate Relations, 970 Burrard Street, Vancouver, British Columbia, V6Z 1Y3 or telephone (604) 663-2653.

WILLISTON RESERVOIR RAISING
ENVIRONMENTAL OVERVIEW

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SUMMARY

The potential for raising the maximum normal reservoir level of Williston Lake by 1.5 m from 672.1 m to 673.6 m was identified during the W.A.C. Bennett Dam Comprehensive Inspection and Review in 1984. Raising the maximum normal reservoir level would add additional storage capacity and result in a benefit to Hydro of some 300 GW.h/a of electricity or approximately two percent of the existing energy capacity of the existing Peace River plants. There would be a decrease of secondary energy of 195 GW.h/a. The net benefit of the firm energy increase would have a value of about $5.7 million per year assuming long-term (autumn 1986) energy values of 28.2 and 14.1 mils/kW.h for firm and secondary energy respectively.

W.A.C. Bennett Dam, completed in 1968 blocked the flow of the Peace River and impounded the upper Peace and the lower Parsnip and Finlay rivers, forming Williston Lake, the largest freshwater body in British Columbia. It has a shoreline perimeter of about 1770 km with a surface area of 177 870 ha at the maximum normal reservoir elevation of 672.1 m. In 1968 the authorized maximum normal reservoir level was 670.6 m but Hydro was authorized to increase it to the higher level in 1972. The reservoir is composed of three major reaches; the Parsnip and Finlay reaches lie south and north respectively and the Peace Reach lies east and west over the former Peace River Valley.

Engineering, Property and Environmental overview studies were undertaken to assess the benefits and costs of the proposal and are summarized in the Overview Study Project Report No. H 1908. The more detailed environmental and property assessments are companion documents to the Project Report. The key environmental issues identified were: the effects on the local residents, the standard of reservoir clearing and the loss of the forest resources.

The area of inundation was calculated using two different data bases, B. C. Hydro's elevation-area curve and planimetered forest cover maps, which resulted in widely divergent estimates of 6650 ha and 15 000 ha respectively. Because of the uncertainty in the area that would be affected, these estimates were assumed to be lower and upper bounds and therefore set the limits of the impacts. A major limitation of the study results was the poor quality of mapping available and hence the poor delineation of the area that would be affected by the reservoir raising. The results of this overview assessment are by their nature preliminary, but are believed to cover the range of possible impacts.

Forestry is the main industry in the Williston area. The resource base has been committed to harvesting to the point that there is a "fibre shortage" and any loss of merchantable timber or timber- producing land would aggravate the situation. It is believed that all of the merchantable timber could be recovered in the pre- flooding clearing and postflooding cleanup resulting in no compensable resource loss. A loss from the Mean Annual Increment of approximately one-half to 1 percent of the Allowable Annual Cut for the Mackenzie TSA would be anticipated. Some forestry infrastructure would have to be protected or replaced. The partially completed causeway at the south end of the Parsnip Reach was not included as its in-service date has not been established. The following table summarizes the costs of possible forestry industry impacts.

The prevailing attitude of persons contacted during the overview study was that complete clearing of the area affected should be a requirement of the project. Clearing costs were estimated using a scenario where it was assumed 80 percent of the reservoir could be cleared prior to flooding and the remainder as post flooding debris cleanup. Based on this assumption, the cost of the B. C. Hydro area estimate of clearing for 6650 ha would be $14,930,000 and for the Ministry of Forests and Lands area of 15 000 ha, it would be $31,160,000.

Costs Associated With Forest Industry Impacts*[1]

	Item	6600 ha	15 000 ha
1.	Standing Crop Resource Loss	0	0
2.	Mean Annual Increment Loss*[2]	$1,210,000	$2,730,000
3.	Road and Bridge Protecting/ Relocating (MO F&L)	$ 723,000	$ 723,000
4.	Log Dump Protecting/Replacing	$2,045,000	$2,045,000
		$3,978,000	$5,498,000

---

*[1] Costs are in 1986 dollars.

*[2] Costs are shown in present (1986) value.

One of the major benefits of the project, aside from the long-term energy benefits would be from employment created during construction, primarily from the clearing program. The number of jobs that would be created and the portion of this benefit that would go to area residents is unknown and would depend on economic conditions at the time the work is undertaken.

Heritage and archaeological resources could be affected by the raising. The preliminary investigation revealed the prehistoric native Indian inhabitants utilized the bench lands rather than the river valleys. These benchlands are in the general vicinity of the reservoir elevation.

Recreation resources in the area would be affected; however, the existing shoreline recreation sites could be redesigned or relocated.

Water quality, which is already high is not expected to be altered. Some increase in mercury could occur as with the original project.

The raising is expected to flood some spawning and rearing habitat of riverine species but could also open access into other areas. Species using the littoral zone of the lake may increase in number as a result of additional habitat created.

The area contains rich and diverse wildlife resources that support active guiding and trapping industries. The flooding would further deplete important ungulate range, particularly for moose. The upland species (sheep, goat, etc.) are not expected by be affected. Impacts to other wildlife, such as waterfowl, furbearers, raptors are not expected to be significant.

At present no other resources have been identified as likely to be seriously affected by the proposed raising.

Additional investigation would be required to confirm the initial findings. The first requirement would be current, accurate aerial photograph and map coverage of the area. This would form the basis of more accurate impact predictions and cost estimates associated with the project.

SECTION 1.0 - INTRODUCTION

1.1 PURPOSE

This overview study was commissioned by System Planning Division to identify major environmental concerns and to determine the nature of studies and attendant costs required to provide a detailed assessment of impacts for the proposed reservoir raising.

1.2 AUTHORITY

General Work Orders 216019 and 216020 issued to Hydroelectric Engineering and System Operations and Maintenance Division respectively authorized Engineering and Environmental overview studies of the proposal to raise the level of Williston Lake by 1.5 m. This report gives the results of the environmental studies while report H1908 contains the results of the engineering investigations and a summary of environmental and property issues. The property assessment is contained in report HR190.

1.3 PROJECT DESCRIPTION

W.A.C. Bennett Dam, completed in 1968 blocked the flow of the Peace River and impounded the upper Peace and the lower Parsnip and Finlay rivers forming Williston Lake, the largest freshwater body in British Columbia. It has a shoreline perimeter of about 1770 km with a surface area of 177 870 ha at the maximum normal reservoir elevation of 672.1 m. In 1968 the authorized maximum normal reservoir level was 670.6 m but was authorized to be increased to the higher level in 1972. The reservoir comprises three major reaches; the Parsnip and Finlay

reaches lie south and north respectively and the Peace Reach lies east and west over the former Peace River Valley (Fig. 1-1).

In the report on the 1984 Comprehensive Inspection and Review of the W.A.C. Bennett Dam it was recommended that the inflow design flood for the project be reduced by about 15 percent by deleting the McGregor component of the flood until such time as the McGregor River Diversion Project is actually built. At that time it was recognized that this lower flood would allow raising the normal maximum level of the lake by about 1.5 m without encroaching on freeboard. It was also pointed out that a dam crest survey had indicated that the minimum elevation was 0.5 m higher than the design elevation and may allow the operating levels to be raised even more. The present study has been restricted to the initial 1.5 m of raising. The principal modifications required at the dam to accommodate the increased levels would be the extension of the spillway gates and modifications to hoisting equipment.

The general operating regime of the reservoir is not expected to change appreciably. The current minimum drawdown elevations would be maintained with the drawdown/fill regimes paralleling those of present conditions.

The increased water level would provide an additional 300 GW.h/a of electricity which is equal to approximately 2 percent of the energy capacity of the existing Peace River plants. The long-term value (autumn 1986) of energy for projects coming on-line in the mid 1990s and beyond is 28.2 mils/kW.h for firm energy and 14.1 mils for secondary energy. Based on these assumed values the net value of the energy benefits would be about $5.7 million per year.

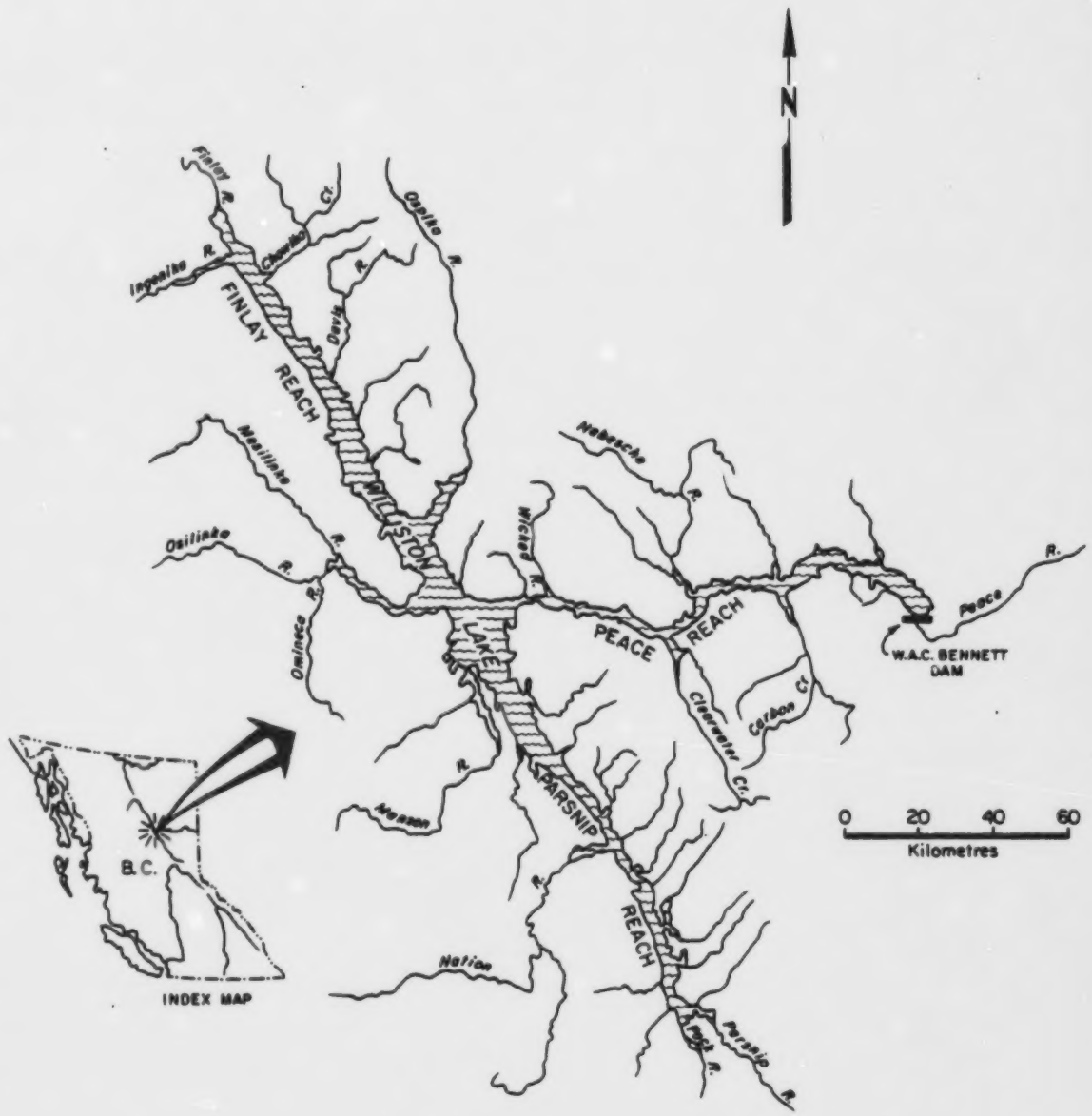

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Figure 1-1

WILLISTON RAISING PROJECT
GENERAL STUDY AREA
AND PRINCIPAL REACHES

1.4 PHYSIOGRAPHY

Williston Lake occupies two physiographic regions, the Cassiar-Columbia mountains and the Eastern Systems (Holland 1964). The Finlay and Parsnip reaches lie in the northern section of the Rocky Mountain Trench. The Peace Reach which lies in an east-west direction bisects the Eastern System.

The valleys of the Finlay and Parsnip rivers are wide with relatively flat bottoms and rising to the mountains to the west and east. The Peace River Valley below Finlay Forks is narrower and cuts through the Rocky Mountains to the east.

Tributary rivers to the Upper Peace River are small and swift flowing. They flow through valleys similar to those of the main river except for being generally narrower and steeper. The tributaries of the Finlay and Parsnip tend to be larger and with a lower gradient.

1.5 CLIMATE

The area is characterized by a continental climate featuring long, cold winters and short, cool summers. Mean daily minimum temperature in January is in the -15°C to -20°C range and often falling below -30°C. July mean daily maximum temperatures are in the 16°C to 18°C range but can reach 30°C. Frost normally occurs around the end of August, however, it can freeze in any month. Precipitation in the region varies widely with 35 to 45 percent of it occurring in the winter as snow. The low elevation areas in the Trench and along the Peace Reach average 400 mm to 500 mm of precipitation annually. This increases to 750 mm to 1000 mm in the Rocky Mountains east of the Finlay Reach.

1.6 BIOPHYSICAL

The Williston Lake watershed drains areas contained within five biogeoclimatic zones. These include: Sub-boreal Spruce, Sub-alpine Englemann Spruce Sub-alpine Fir, Boreal White and Black Spruce, Spruce-Willow-Birch and Alpine Tundra zones. The Sub-boreal Spruce zone is the predominant zone occurring adjacent to the reservoir on both the Finlay and Parsnip reaches, giving way to the Boreal White and Black Spruce zone north of the Chowika River and Ingenika Arm (Meidinger et. al. 1986). The latter Boreal type dominates the valley of the Peace Reach (Krajina 1973).

1.7 FAUNA

This area is faunally rich, especially with respect to ungulates and carnivores. Ungulate species include moose, deer, elk, caribou, thinhorn sheep and goat. Black and grizzly bear, lynx, wolf, coyote, fox, wolverine, fisher, marten, mink and weasel are some of the more frequently found carnivores. Many other mammals, birds, and reptiles inhabit the area, some however only on a seasonal basis. Whitefish, kokanee, rainbow trout, Arctic grayling and Dolly Varden are the main sportfish. Other fish include suckers, squawfish, shiners and chub.

SECTION 2.0 - METHODOLOGY AND AVAILABLE INFORMATION

This study comprised a review of the available literature and discussions, either in person or by telephone, with government agency personnel, industry representatives, community leaders, Indian Band representatives and others (Appendix A). The available budget and the schedule allowed for only a cursory reconnaissance flight of the existing reservoir.

A major shortcoming of the present overview study, has been the lack of adequate information to define the area that would be inundated by the proposed raising. Two sources of area information were available:

1. The B. C. Hydro area elevation-curve developed in the mid 1970s indicates an approximate area to be inundated of 6650 ha.

2. Ministry of Forests and Lands information, based on a B. C. Hydro photogrammetric assessment of the flood line marked on the forest inventory maps, indicates approximately 12 000 ha for the area for which there were forest cover maps and it is estimated that there could be an additional 3000 ha for which there were no forest cover maps, resulting in a total area of some 15 000 ha. The accuracy of both the existing and the proposed future flood lines on these forest cover maps is uncertain.

As a result of these differences, it has not been possible to satisfactorily quantify and evaluate the impact of the proposed raising. This has resulted in a range of values being given for the various discipline impacts.

SECTION 3.0 - SOCIO-ECONOMICS

3.1 DESCRIPTION

(a) Historical and Cultural Background

The first inhabitants of the area were the Sekani and Carrier of the Athapaskan linguistic group. The tribes were nomadic hunters and gatherers and used the river systems extensively for these activities. The first European contact with the Sekani of the Parsnip River and the Carrier of the Upper Fraser River was made by Alexander Mackenzie in 1793 on his journey to the Pacific. Simon Fraser established a series of fur trading posts in 1805 at Fort MacLeod, Fort Nelson and Fort St. John. Following the decline of the fur trade came a brief period of gold exploration. The area remained the domain of prospectors, fur traders, trappers and hunters until well into the 20th century.

Indian Reserves were established in 1916 around the Hudson Bay trading posts at Fort Ware and Fort Grahame. In 1952 the John Hart Highway was completed from Prince George to Dawson Creek and small sawmills were established throughout the region. Prior to construction of the W.A.C. Bennett Dam the population was estimated at approximately 500, about half of which were Indians (ELUC Secretariat 1980).

Government approval for the creation of Lake Williston was given in 1962. In 1966 Finlay Forest Industries announced plans to develop a mill and soon after B. C. Forest Products proceeded to develop pulp and lumber manufacturing facilities at Mackenzie.

(b) Regional Perspective

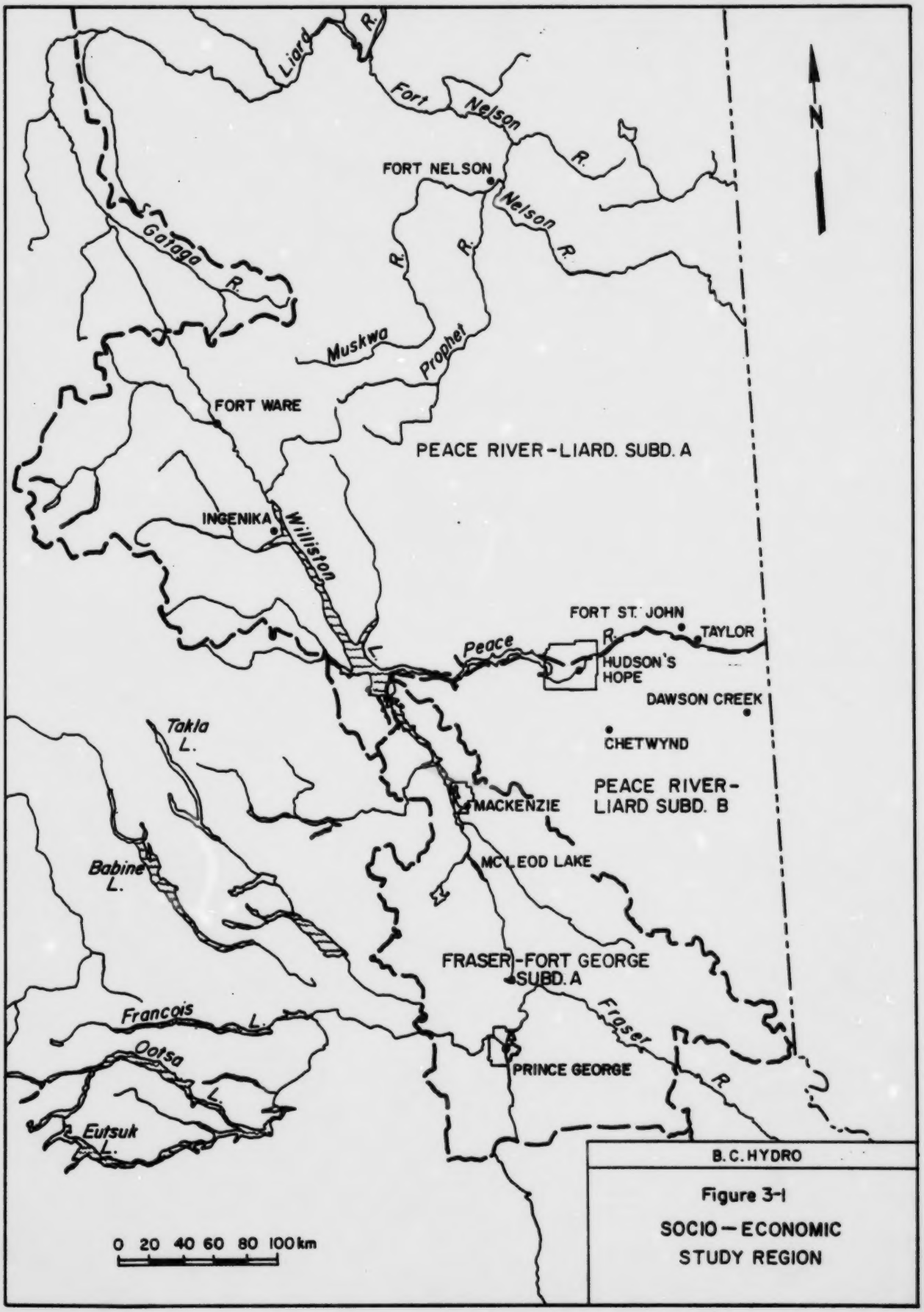
The study region is defined to include Subdivision A of the Fraser-Fort George Regional District and Subdivision A of the Peace River-Liard Regional District (Fig. 3-1). Total population in the region is 23 121 (1981).

The regional economy is largely based on the forest industry. Much of the manufacturing, construction, transportation and services are related to this industry and Prince George serves as the major service centre for the region.

In terms of transportation, Prince George is served by major airline carriers while both Mackenzie and Hudson's Hope have smaller airstrips with charter services without scheduled flights. The B. C. Rail mainline operates through the region with a spur line to Mackenzie. The provincial highway network connects Mackenzie, Hudson's Hope and MacLeod Lake but not the Ingenika and Fort Ware communities.

The labour force, as of 1981, comprised 10 830 persons with a participation rate of 83.1 percent for males and 50.1 percent for females. The unemployment rate in 1981 was slightly over 9 percent for the Fraser-Fort George Subdivision A and over 6 percent for the Peace River-Liard Subdivision A. Since 1981 the provincial economy has suffered a recession and the current unemployment figures are probably much higher. Data for the region were unavailable but, for comparison, the unemployment rate for B. C. in 1981 was 6.7 percent and in 1985 was 14.2 percent.

Average family income was $29,196 for the Fraser-Fort George Subdivision A and $28,196 for Peace River-Liard Subdivision A. These are close to the B. C. average of $29,132.


Liard R.
Fort Nelson R.
FORT NELSON
Nelson R.
Gataga R.
Muskwa R.
Prophet R.
FORT WARE
PEACE RIVER-LIARD. SUBD. A
INGENIKA
Williston L.
FORT ST. JOHN
TAYLOR
Peace R.
HUDSON'S HOPE
DAWSON CREEK
CHETWYND
Takla L.
PEACE RIVER-LIARD SUBD. B
MACKENZIE
MCLEOD LAKE
Babine L.
FRASER-FORT GEORGE SUBD. A
Francois L.
Ootsa L.
Fraser R.
PRINCE GEORGE
Eutsuk L.
N
0 20 40 60 80 100 km
B.C. HYDRO
Figure 3-1
SOCIO-ECONOMIC STUDY REGION

(c) Government

Federally, the study area lies within the Prince George-Peace River constituency. Provincially, the Prince George North and North Peace ridings cover the area of influence.

The study region is included within the two regional districts of Fraser-Fort George and Peace River-Liard which provide economic development assistance, hospital funding and municipal finance authority loans.

The District of Mackenzie and the District of Hudson's Hope are governed by a district council composed of one mayor and six aldermen elected at large for 2-year terms of office.

(d) Communities

1. Mackenzie

The major economic activity of the District of Mackenzie is generated by the two pulp-sawmill complexes. The forest processing industry is based on logs towed on the reservoir or transported by truck. The community also acts as a service and retail centre for the outlying population.

The 1981 population was 5890. The residents are very young relative to the other incorporated communities in the Regional District of Fraser-Fort George and British Columbia. The 1981 census shows 79 percent of the population being under 35 years of age compared to 69.4 percent for the Fraser-Fort George Regional District and 57.2 percent for B. C.

In 1981 the labour force of Mackenzie numbered 3920 persons with a participation rate of 91.8 percent for males and 54.6 percent for females. The unemployment rate was 6.9 percent and 15.5 percent, respectively. The average family income was $32,732.

The District's water supply is from Morphee Lakes and Mackenzie is served by a gravity sewage system with treatment lagoons.

Health services are provided through the 18 bed Mackenzie District Hospital. Three physicians and three dentists are available.

Three elementary schools and one secondary school are located in Mackenzie and a campus of the College of New Caledonia provides some post secondary courses.

A wide range of recreation facilities are available including an indoor pool and arena. These facilities complement the naturally available recreation opportunities such as fishing, hunting, cross country skiing, hiking and others.

A local newspaper is published weekly.

2. Hudson's Hope

The District of Hudson's Hope is located 89 km southwest of Fort St. John and 7 km from the Peace Canyon Dam on Highway 28. The economy of Hudson's Hope has been based on the development of the W.A.C. Bennett Dam, completed in 1968, and the Peace Canyon Dam, completed in 1980. Many of the operations staff for the generating stations reside in

Hudson's Hope. The forest industry also provides some economic activity.

The population in 1981 was 1365 and had grown only slightly from the 1976 population of 1330.

The labour force numbers 620. The participation rate was 74.1 percent for males and 44.9 percent for females. Unemployment rates in 1981 were 7.5 percent and 18.2 percent, respectively. Average family income was $29,271 in 1981, very similar to Mackenzie and the B. C. average.

The town has one elementary and one secondary school with some post secondary classes available through Northern Lights College.

Recreation facilities include a curling rink, community hall, indoor and outdoor cinemas, and swimming pool. The surrounding lakes, particularly Lake Williston, provide valued outdoor recreation.

3. Ingenika

Prior to construction of the W.A.C. Bennett Dam, there was one Band, the Finlay Forks Band which was split into the Finlay River Band (now Ingenika) and the Fort Ware Band. The original Finlay Forks Band had two reserves, Finlay Forks Indian Reserve 1 (also called Fort Grahame) and Police Meadows Indian Reserve 2. About 40 members lived permanently at Fort Grahame on Finlay Forks Indian Reserve 1 but for the most part the people were nomadic and lived along the Finlay River in trapping cabins. No one lived permanently on the Police Meadows Indian Reserve 2. Figure 3-2 shows the location of the Indian Reserves and communities in the region.

The Williston Reservoir flooded Fort Grahame and a small sawmill, Cattermole Mill at Finlay Forks which employed 33 Indians (Boivin 1982). Some of the people relocated in Fort Ware and others moved to the two new reserves near MacKenzie, purchased by B. C. Hydro to replace Fort Grahame. These are Tutu Creek Indian Reserve 4 and the Parsnip Indian Reserve 5 (see Table 3-1 and Fig. 3-2 for location and size of reserves).

Although the Band members agreed at first to relocate to the Parsnip Reserve, most of them subsequently (1971) decided that they had been poorly advised by Indian Affairs officials to exchange Fort Grahame for the two new reserves. They felt that the exchange did not properly compensate them for the forced relocation and they expressed the wish to have an additional reserve at Ingenika Point. When they were unable to arrive at a mutually satisfactory arrangement with government agencies, most of the Band moved to the more isolated Ingenika Point regardless of the fact that it was not Reserve land (Veit 1978). The Band is interested in obtaining a new Reserve at the northwest end of Lake Williston at Hydro Creek. Access to the new reserve over the Ingenika Arm could be at Swannell Creek. A Community Development Plan for the Band is being prepared.

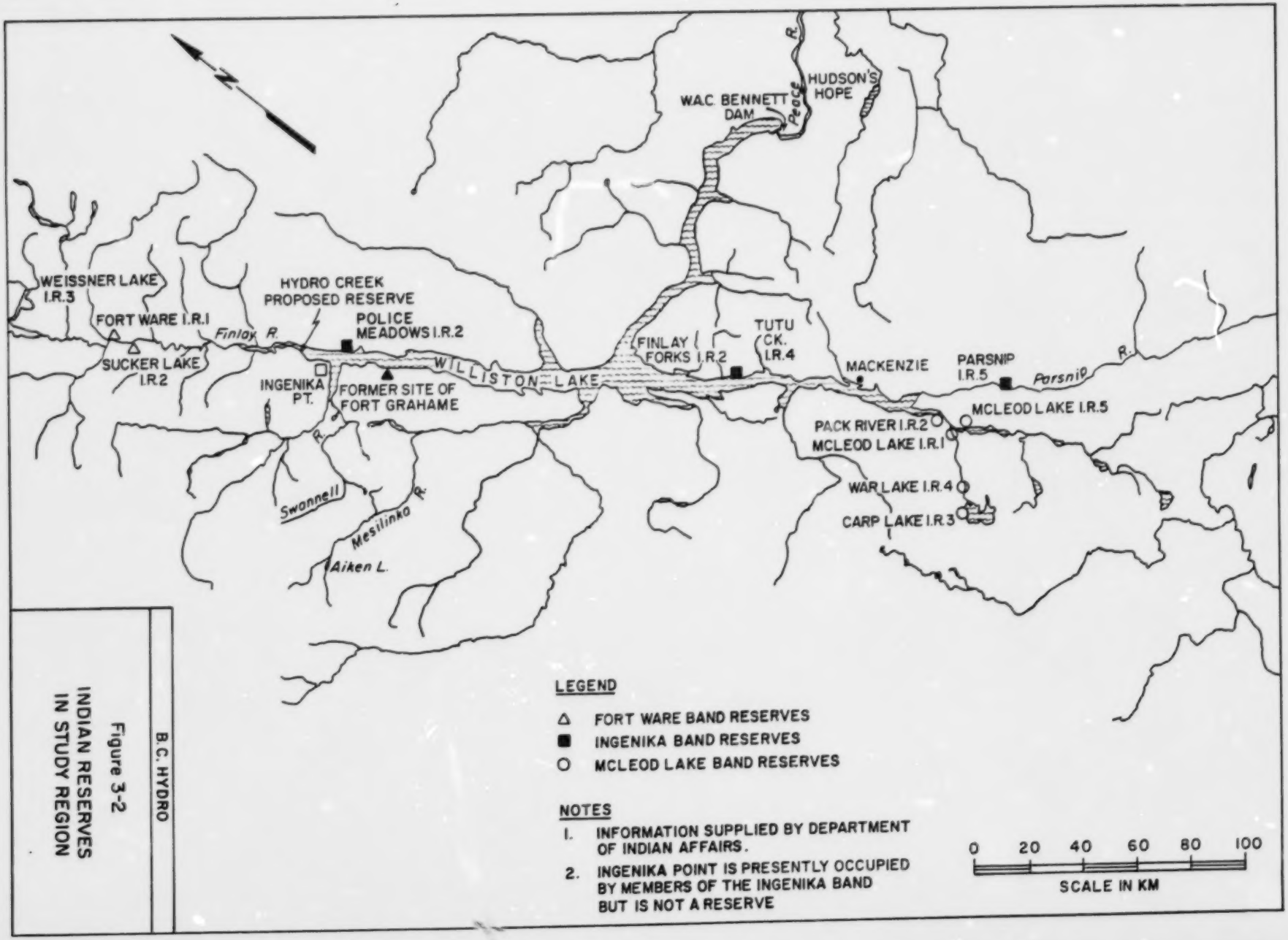
As of August 1986 the Ingenika Band has separated into two bands with the larger group of 152 retaining the Ingenika name and continuing to pursue the new Reserve at Hydro Creek. The second is the Tsayta Nay Band which has relocated near Aiken Lake, a tributary of the Mesilinka River (H. Urhann, pers. comm.). The two Bands intend to continue dealing as a single entity with Hydro.

Table 3-1

Indian Reserves in Study Region

	Approximate Area (ha)
Fort Ware Band	
Fort Ware Indian Reserve 1	388
Sucker Lake Indian Reserve 2A	2
Weissener Lake Indian Reserve 3	2
Ingenika Band	
Police Meadows Indian Reserve 2	129
Tutu Creek Indian Reserve 4	37
Parsnip Indian Reserve 5	34
McLeod Lake Band	
McLeod Lake Indian Reserve 1	116
Pack River Reserve 2	117
Carp Lake Reserve 3	5
War Lake Reserve 4	3
McLeod Lake Reserve 5	7

Source: Department of Indian and Northern Affairs.


W.A.C. BENNETT DAM
Peace R.
HUDSON'S HOPE
WEISSNER LAKE I.R.3
FORT WARE I.R.1
Finlay R.
SUCKER LAKE I.R.2
HYDRO CREEK PROPOSED RESERVE
POLICE MEADOWS I.R.2
INGENIKA PT.
FORMER SITE OF FORT GRAHAME
WILLISTON LAKE
FINLAY FORKS I.R.2
TUTU CK. I.R.4
MACKENZIE
PARSNIP I.R.5
Parsnip R.
MCLEOD LAKE I.R.5
PACK RIVER I.R.2
MCLEOD LAKE I.R.1
WAR LAKE I.R.4
CARP LAKE I.R.3
Swannell R.
Mesilinka R.
Aiken L.
LEGEND
FORT WARE BAND RESERVES
INGENIKA BAND RESERVES
MCLEOD LAKE BAND RESERVES
NOTES
1. INFORMATION SUPPLIED BY DEPARTMENT OF INDIAN AFFAIRS.
2. INGENIKA POINT IS PRESENTLY OCCUPIED BY MEMBERS OF THE INGENIKA BAND BUT IS NOT A RESERVE
0 20 40 60 80 100
SCALE IN KM
B.C. HYDRO
Figure 3-2
INDIAN RESERVES IN STUDY REGION

Travel on the newly created reservoir was dangerous and interrupted subsistence (hunting, fishing and trapping) activities and social contact with relatives. Sloughing also affected some tribal burial grounds.

The Ingenika and Tsayta Nay Bands are part of the Carrier-Sekani Tribal Council. The Bands elect a Chief and Council according to custom which is not at specifically defined intervals but when required. A new Chief with four Councillors has recently been elected for the Ingenika Band and a former Chief of the Ingenika Band is the Chief of the Tsayta Nay Band.

Since the time when the basic social and economic structures of their society were severely disrupted, the Ingenikas have been seeking means to revive their community.

There are presently 152 members in the Ingenika Band. The main settlement is at the Point with another at the Ingenika mine site on Ingenika Arm, they have 35 houses on two settlements. There is a store and church in the village and a school built for and run by the Band. They have no running water and although the store and school were equipped with electricity, the diesel station was not functioning at the time of the visit.

The Tsayta Nay Band, with 42 members, has just recently moved to the Aiken Lake area and at the writing of this report no information was available on the community structure or services.

Communication with other communities is difficult. A gravel road link was established to Vanderhoof a few years ago and the Band has established an office there. The Forest Service operates an airstrip at Ingenika Point.

There are few jobs for the Band members, many of whom want to work. Some years there are occasional jobs clearing for B. C. Hydro and fire fighting with the Ministry of Forests and Lands. Some guiding and trapping is done.

In the future their aspirations are to improve the living conditions of their members and they hope to be better able to pursue traditional economic activities and obtain wage employment.

4. Fort Ware

The Fort Ware Band has three reserves as indicated in Table 3-1. The community of Fort Ware is located at the confluence of the Fox and Kwadacha rivers on the Finlay River about 60 km north of Williston Lake. There are no roads into the community and access is by air or water.

Williston Lake created a problem for the Band by disrupting social relations and access to wildlife resources and by flooding important cultural areas. The "Finlay Plug" has, until the last 2 years, plugged the north end of the lake making boat travel to the Finlay River impossible. The supply of food and materials is extremely costly and irregular. B. C. Hydro and the B. C. Forest Service have at times transported supplies around the log jam.

The Fort Ware Band is part of the Kaska Dena Tribal Council which was established in 1981 to represent the interest of the Kaska people.

The Band has a membership of 221 people with 165 living at Fort Ware and other members living at Ingenika Point. A school, medical station and general store are located at Fort Ware and a modern community centre was completed in 1986 which is equipped with electricity and running water. There are about 44 houses with the newer ones having electricity and water.

The employment possibilities are limited with only seasonal work sometimes available in logging, fire fighting, debris clearing and guiding. House building has recently provided some work. Hunting, trapping and guiding provide food and some income.

The Band believes a road will probably be built into the community within a few years. Reportedly, the road survey will be undertaken with funds from Department of Indian and Northern Affairs and B. C. Forest Products. Most Band members are apprehensive of changes this could cause. While access for food and supplies will be improved the effect on the social structure could be severe.

5. MacLeod Lake Band

The MacLeod Lake Band has five reserves, three of which have dwellings on them. MacLeod Lake Indian Reserve 1 and Pack River Indian Reserve 2 are the main residential reserves. There are four separate settlements with two located on the lake on either side of MacLeod River, one between the Pack and MacLeod rivers and one on the hill above the lake. The

settlements have a total of 22 dwellings. A smaller reserve, MacLeod Lake Indian Reserve 5 adjoins the highway and has been inhabited with the construction of two houses.

As a result of the creation of Williston Lake, prime trapping and hunting areas were lost and the use of the river systems to maintain access with relatives was stopped. Some Band members suggest that this has directly contributed to the current difficult period of high socio-cultural conflict and economic stagnation. The Band considers that significant compensation for their losses is still required while the Hydro position is that full compensation was paid.

The MacLeod Lake Band is independent of tribal council affiliations but is supportive of the Union of Indian Chiefs.

The Band has 234 members with 80 living on the reserves. During the last 20 years the total membership has been increasing while the on-Reserve population has been declining, however, in the most recent years it has started to increase. The Band population is relatively young and will continue to have an expanding labour force through the 1990s.

Services include a piped water system, however, there is often insufficient pressure for operation. Only a small log building is available as a community facility although studies have been completed for a community centre. There is no first aid station or hospital facilities. Younger students attend the MacLeod Lake Elementary School but students go to Prince George for secondary school.

Little employment is available to members living on Reserves, although interest in finding wage employment is high,

particularly for males. Some seasonal clearing work is available from B. C. Hydro, Westcoast Transmission and the Ministry of Forests and Lands.

Band members hold 11 registered trap lines and one guiding area. Trapping and guiding provide some income with the guiding resulting in about $12,000 in wages each year. While fishing is still an important source of food, it has declined since Carp Lake became a Provincial Park and the increased pressure on stocks by sports fishermen. Hunting is still common and wild game remains an important economic and cultural resource.

At one time the Band was part of the Sekani Tribal Council with the Fort Ware and Ingenika Bands, but are now independent. The Band is administered through offices in Prince George.

The Band's goals emphasize economic independence, self-sufficiency and control over natural resources.

6. Rural

Although precise numbers are not available, there are rural residents some of whom may own or use cabins near the reservoir. Included in those would be trappers or guides.

3.2 IMPACT ASSESSMENT

The workforce required to modify structures at the W.A.C. Bennett Dam would be small and would complete the work over one or two seasons. Of greater importance are the employment effects from reservoir clearing

which are difficult to define before a decision is made on the extent of the clearing to be undertaken. This type of employment would probably be seasonal but could last 3 to 5 years. Protecting, repairing and replacing infrastructure will provide temporary employment, probably over one or two years. Mitigation and compensation measures could also result in employment opportunities during and after construction.

Some forest producing areas would be flooded causing a small reduction in the potential volume of timber cut annually. This reduction appears too small to cause workforce reductions for the forest industry.

Direct effects on the Reserve lands of the Fort Ware Band are unlikely this time. Regarding the Ingenikas, the Chief reports that Police Meadows Indian Reserve 2 has been flooded in high water but it is uncertain if this is due to runoff or the reservoir. The location of gravesites would need to be investigated to determine if any would require protecting or relocating. The effects on the possible new reserve at Hydro Creek and an access road are unknown and need investigation. It is possible that three reserves of the MacLeod Lake Band could in some way be affected. Pack River Indian Reserve 2 has two structures, MacLeod Lake Indian Reserve 5 has two new houses and MacLeod Indian Reserve 1 is the main residential community. It is not known if any relocation of dwellings would be required. No direct affects are expected on the Tsayta Nay Band community at Aiken Lake.

It is likely that some of the lands used by the native people for hunting, fishing, trapping and other traditional activities such as berry picking would be lost. This could erode traditional subsistence activities and income sources. Whether the changes would affect cultural integrity is unknown at this time.

Both the Ingenika and Fort Ware Bands could experience transportation problems if there is an increase in the amount of debris on the

reservoir that leads to the reforming of the "Finlay Plug". In this event transportation of food and supplies would become more costly and could require special arrangements for air or ground transportation.

Elsewhere around the reservoir and the adjoining rivers, approximately 45 private landowners may have some effect on their properties. The extent of this and the socio-economic implications will not be known until further assessment occurs.

A major public concern voiced by the Districts of Mackenzie and Hudson's Hope among others would relate to the amount of clearing that would be done. To minimize disruption of recreational use of the reservoir, clearing would certainly be needed near the communities and on navigation routes.

Public reaction to the project will also be related to the effect on the forest industry and jobs in Mackenzie. At this time it is believed there would be no loss of employment as a result of the project.

SECTION 4.0 - FORESTRY

4.1 GENERAL

Williston Lake is situated within the Prince George Forest Region which includes northeastern British Columbia.

The forest industry provides the majority of the employment and economic activity for the Prince George region. Regionally, the industry got its start with the tie-cutting and sawmilling boom stimulated by the Grand Trunk Pacific Railway extension through the Yellowhead Pass. Up to the 1960s the industry comprised widely scattered portable bush mills. The construction of three pulp mills in Prince George dramatically changed the utilization of forest resources in this region. Two pulp mills opened in Mackenzie in 1973 and 1974 following the signing of Pulp Harvesting Agreements. These agreements were made with major companies prepared to make capital commitments to construct pulp mills, augmented by guarantees of supply from the Prince George Special Sales Areas (Ministry of Forests 1980).

The Prince George region is 13 713 460 ha of which the Mackenzie TSA comprises approximately 5 200 000 ha and encompasses the watershed of Williston Lake (Ministry of Forests 1980).

Williston Lake covers some 178 000 ha primarily in the Mackenzie T.S.A. The proposed raising would add an additional 6650 ha to 15 000 ha to that total depending on the method of area calculation used (refer to Section 2.0). Table 4-1 provides a breakdown of the major forest types that would be affected and the approximate areas for each.

Table 4-1

Forest Land Affected by Williston Raising
(B. C. Hydro Elevation Area Curve)

Forest Type	Area (ha)	Composition (%)
Mature coniferous	2610	39.2
Immature coniferous	1280	19.2
Mature deciduous	150	2.3
Immature deciduous	1200	18.0
Non-productive	1410	21.3
	6650	100.0

Table 4-2

Forest Land Affected by Williston Raising
(MOF&L Area)

Forest Type	Area (ha)	Composition (%)
Mature coniferous	5 880	39.2
Immature coniferous	2 880	19.2
Mature deciduous	340	2.3
Immature deciduous	2 700	18.0
Non-productive	3 200	21.3
	15 000	100.0

4.2 IMPACT ASSESSMENT

(a) Description

Forestry impacts to standing crop, Mean Annual Increment and Capital Improvements were considered.

Standing crop refers to timber that is immediately available for harvesting but is not necessarily scheduled for harvesting in the Ministry's current 5-year planning framework due to access, the required species mix, or the schedule of harvesting to meet yield criteria (C. Nelson, D. Hargraves and J. Tuck, pers. comm.). These are the stands considered in calculating the Annual Allowable Cut (A.A.C.) which is the estimated volume of timber that can be harvested on a sustained yield basis.

The value of the forest resource to the Province is calculated using the Stumpage Rate. This value, set by the Ministry is meant to cover costs associated with producing and harvesting the resource and includes reforestation, silviculture, forest protection, access development, timber management and others. Market conditions influence the stumpage rate and thus it can fluctuate quite widely, for example, the rate in 1986 was around $\$1.50/m^3$ but has been in the $\$12.00/m^3$ range in recent years (D. Hargraves and J. Tuck, pers. comm.). The rate used for this study was $\$4.56/m^3$ (1986$).

The Ministry would normally require compensation for the loss of standing crop or the permanent removal of productive lands. If the standing crop is utilized, no compensation for that component would be required.

Mean Annual Increment (MAI) is the volume of timber estimated to be produced annually taking into consideration climate, growing

season, soil type and other parameters. The Ministry includes all land with the potential to produce coniferous forest, including immature, mature, logged and burned. Unlike the value of the standing crop which has a one-time value, the MAI value accumulates each year, therefore its value must be calculated over the life of a project. To compare this future value the net present value of the resource is calculated by applying the corporate discount rate. The net present value of the resource would vary little whether using the project life, the Ministry's expected growing cycle for pine or spruce (80 and 100 years, respectively) or in perpetuity. This value is compensable as the ability of this land to produce trees is foregone forever.

Capital investments include roads, bridges, log dumps, plant and other improvements that have been constructed to enable the resource to be extracted. For this study all roads, bridges, log dumps etc. being used and affected, would be protected, repaired or replaced. The costs reflect the current values for these activities. The proposed causeway at the southern end of the Parsnip Reach has not been included as the schedule for its completion is indefinite.

(b) Calculation

(i) Standing Crop Resource Loss

The likelihood of having to totally clear the reservoir probably by a combination of pre-flooding clearing and post-flooding debris salvaging has led to the assumption that all of the merchantable timber would be recovered. This could require the Ministry to adjust some of the cutting schedules of B.C.F.P. and F.F.I. over the 3 to 5-year clearing schedule. (C. Nelson, D. Hargraves and J. Tuck, pers. comm.) It is believed any merchantable timber not taken during the

clearing could be recovered in the 2 years following the raising. With this assumption there would be no resource loss requiring compensation.

(ii) Mean Annual Increment Loss

The Ministry calculated the Mean Annual Increment (MAI) loss for this study using only those areas presently growing mature and immature coniferous forest. The MAI was calculated by the Ministry to be 3.42m^3/ha and the stumpage rate \$4.56/m^3 (J. Tuck, pers. comm.). The net present value of the resource was calculated in perpetuity by using the Corporate discount rate of 5 percent (K. Peterson, pers. comm.). Table 4-3 shows the calculations which has been included in the cost estimates as part of the contingencies for the project.

(iii) Capital Improvements

Various sections of forestry roads would be affected around the reservoir, which would require raising, protecting or replacing to maintain the access. The major section of road work would be to prepare a new access route to the low level ice bridge which crosses to the east side of the reservoir from near the mouth of the Pack River. The reservoir raising would flood much of the low-lying area on the south end of the Parsnip reach and cover the existing access. This ice bridge is essential to the present winter hauling program as it makes it possible to haul directly to the mills with the wide trunk off highway trucks. Without it the trucks would have to be off loaded and highway legal trucks loaded which would increase the time and cost of delivery. The low level ice bridge consists of a low causeway across the river flats at this location, a timber bridge across the main channel of

Table 4-3

Mean Annual Increment Loss Value

Area of Timber (ha)[1]		x	Annual Rate of Production (m^3/ha)[2]	x	Stumpage Rate $/$m^3$[3]	÷	Discount Rate[4]	=	Value of Resource Loss
BC Hydro	3890	x	3.42	x	$4.56	÷	0.05	=	$1,213,307 (round to $1,210,000)
MOF&L	8760	x	3.42	x	$4.56	÷	0.05	=	$2,732,279 (round to $2,730,000)

Notes:

1 Includes mature and immature coniferous forest land.

2 Annual rate of production provided by MOF&L.

3 Stumpage Rate 20-year average provided by MOF&L.

4 B. C. Hydro's corporate discount rate for 1986.

the Parsnip River and the ice across the Reach. The timber bridge is destroyed on an annual basis when the ice breaks up in the Parsnip River. The loaded logging trucks hauling to the mills use this facility while the empty trucks cross the reservoir at Mackenzie on the ice. The low level ice bridge is particularly important in those years when there is too much ice to operate the ferry that crosses the reservoir at Mackenzie, but the ice is too thin to install an ice bridge that would support loaded trucks crossing the reservoir (this has occurred for the last 5 or 6 years). The reservoir must be at El. 668.4 m or lower for this bridge to be installed. Several regular bridges will also require work, primarily protective armouring, however some may require relocating. Table 4-4 shows the main sections of road and bridges requiring work and the estimated cost.

Locating log dumps on the reservoir is difficult because of the large fluctuation in water levels. It is preferable to find a location that can be used year-round since in the summer log bundles need to be dumped directly into the water for towing to the mills. In the winter bundles are stored on the ground so they will float as the reservoir fills. Large, relatively flat areas are required to store the large number of bundles. It is felt the 1.5 m raising would affect the operability of many of the present log dumps (S. Potter and E. Gillett, pers. comm.). It is unknown at present how significant the impacts will be on any given dump. The F.F.I. camp, airport and dump complex at Mesilinka which is located close to the edge of the reservoir and is already adversely affected by water elevations in excess of 672.1 m could be severely affected by the raising.

B. C. Forest Projects and Finlay Forest Industries personnel (S. Potter and E. Gillett) provided estimates of the costs

Table 4-4

Roads and Bridges Affected by Williston Raising

	Roads	Length of Grade
1.	Parsnip F.S.R. @ Morfee Creek	600 m
	@ Morfee Creek to Hydro rec. site	685 m
2.	Parsnip - Chico	600 m
3.	Finlay F.S.R. @ Pack River	2 000 m
	@ Tsedeka Creek	1 200 m
	@ Gataiga Causeway	450 m
4.	Finlay-Davis F.S.R. @ Davis River	450 m
	@ Chowika R. Bridge	600 m
5.	Low level ice bridge access road (new route)	6 800 m
		13 385 m (round to 13.4 km)

Average construction cost per kilometre used was $40,000.

13.4 km x $40,000/km = $536,000*

Bridges	Estimated Cost
Tsedeka Creek Bridge	$ 50,000
Davis River Bridge	$ 35,000
Pack River Bridge	$ 87,425
Unnamed Creek at 10.5 km Finlay Main	$ 15,000
	$187,425* (round to $187,000)*

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*Cost information provided by Ministry of Forests and Lands.

associated with protecting and/or relocating log dumps, these are shown in Table 4-5.

(iv) Causeway

The Ministry and forest companies have partially completed a causeway to improve hauling efficiency from the west side of the reservoir. The earth fill structure would cross the reservoir from the vicinity of Lignite Creek on the west shore north to a point of land west of Gatiaga Creek on the east shore. This structure would reduce the one way haul distance by an estimated 30 km to 47 km (depending on the route), eliminate the effect of high water levels on ice bridges and permit the use of off-highway vehicles year round. This structure has been "on the books" for some time, and apparently is economically feasible, however very little work has been completed. The Ministry estimates $1 million has been spent so far with an additional $5 to $5.5 million required to complete the project for use at the El. 672.1 m reservoir level. They estimate an additional $2 million would be required to raise it for use at the El. 673.6 m reservoir level (C. Nelson, pers. comm.).

Since the schedule for completing the causeway is indefinite the cost of raising the causeway has not been included as a project cost. However, if the causeway is built when the reservoir is raised then there would be no need for the low level ice bridge or the access road.

Table 4-5

Costs Associated With Forest Industry Impacts[1]

	Item	6650 ha	15 000 ha
1.	Standing Crop Resource Loss	0	0
2.	Mean Annual Increment Loss[2]	$1,210,000	$2,730,000
3.	Road and Bridge Protection/ Relocation (MOF&L)	$ 723,000	$ 723,000
4.	Proposed Causeway	0	0
5.	Log Dump Protection/Replacement	$2,045,000	$2,045,000
		$3,978,000	$5,498,000

1 Costs are in 1986 dollars.

2 Costs are shown in present (1986) values.

SECTION 5.0 - RESERVOIR CLEARING

5.1 BACKGROUND

In keeping with commonly accepted approaches to resource development in the early 1960s, the primary concern in preparing the basin were:

1. hydroelectric power generation, and
2. commercial navigation for log transport.

These required only limited clearing which could be carried out to varying standards. The result was large areas of standing dead trees and subsequently large mats of floating debris once the flooding began.

With changing of public attitudes toward the environment through the 1960s the need for a broader plan for reservoir clearing became evident. This led to more attention to recreation and the needs of smaller commercial users, such as guides and outfitters, in the establishment of clearing priorities and clearing standards.

When the decision was made to develop Williston Lake as a storage reservoir the basin was a virtually untouched forest resource varying from prime timber to non-merchantable scrub.

Of the 1660 km^2 of flooded land, about 80 percent was forest covered. Prior to impoundment, efforts were initiated to remove marketable timber below El. 672.1. Because of the limited time available, the inaccessibility of the forest area, and lack of timber processing plants, total clearing on the inundated lands was not possible. Instead, strategic channels and harbours in the Parsnip Reach were cleared to permit navigation after impoundment with a view toward an ongoing water-based salvage program. As much merchantable timber as

possible was removed or felled for post- flood salvage. It was intended that subsequent drawdown periods would be used to clear and dispose of the residual debris. Considering the time constraints, access problems, and lack of timber processing plants, the overall plan for clearing was probably the most reasonable approach. Some refinement requiring salvage operators to dispose of or control the non-merchantable component of the floating debris may have increased the quantity of material salvaged and resulted in a more efficient post-filling cleanup.

After the reservoir started to fill in 1968 an extensive program of cleanup activities was initiated, the objectives of which were as follows:

1. To keep the dam intake and powerhouse free of debris so that it would not interfere with their operation even in extreme situations.

2. To remove sufficient floating debris and other navigational obstructions to permit use of the reservoir for commercial navigation related to forest access and log transportation.

3. To clear navigable rivers of debris. The Finlay River is particularly important since it is the traditional access to the settlement of Fort Ware.

4. To clear navigational obstructions from areas frequented by recreational users.

5. To improve aesthetic quality of the shoreline by removing standing flood-held trees.

As the magnitude of the task of post-flood clearing became apparent, many techniques were discussed and attempted. Because of the very

large amount and varying types of navigational obstructions including floating debris it was soon apparent that the post-flood cleanup would be very costly and require many years to complete.

Initially, the post-filling cleanup was concentrated at the east end of the Peace Reach near the W.A.C. Bennett Dam to protect the spillway and intake structures, and on the Parsnip Reach to clear navigational channels and forest access locations. Prevailing winds caused major concentrations of floating debris at the east end of the Peace Reach and the north end of the Finlay Reach. Hence, most of the floating debris removal and disposal has been concentrated at these two locations. Emphasis has been placed on large volumes that can be disposed of at the lowest unit cost.

The progress made in cleaning up the reservoir has substantially reduced the navigation impediments and enhanced the recreation potential. Should the reservoir become "substantially clear" in accordance with the past government direction in this regard, a shift to a less intensive and expensive clearing program could occur, focusing on areas of high recreational use potential. Were the debris to increase in volume to a level that would impede navigation, a more intensive program would be reinstated to address the situation.

5.2 IMPACT ASSESSMENT

The original reservoir, as a result of continuous cleanup effort, is now becoming usable for commercial and recreational activities and to go back to the previous status would not be acceptable (E. Gillett, pers. comm.). Virtually everyone contacted about the project were of the opinion that total clearing would be required, however whether total clearing is practical and economically feasible is unknown at this time. Regardless of the level of reservoir clearing undertaken, a post-reservoir flooding cleanup program would be required.

Four scenarios representing four degrees of clearing were selected to give a range of possible costs, (Table 5-1). In all cases it was assumed that there would be 85 percent machine clearing and 15 percent hand clearing. The scenarios are:

Scenario 1: One hundred percent of the additional reservoir area would be cleared.

Scenario 2: Eighty percent of the additional reservoir area would be cleared.

Scenario 3: Sixty-seven percent of the additional reservoir area would be cleared including heavy use areas.

Scenario 4: Thirty-three percent of the additional reservoir area would be cleared including areas around population centres, recreation sites, fish bearing streams, industrial sites and the dam.

Clearing costs were based on previous experience at Hydro for transmission line right-of-way clearing (the band to be cleared around the lake would average 40 m) which averaged $1500/ha by machine operation and $5000/ha by hand (J. Barker, pers. comm.). These costs were increased by 20 percent, to $1800/ha and $6000/ha, respectively in consideration of the inaccessibility of parts of the reservoir and the short work season.

It was felt that it would not be practical to achieve 100 percent clearing due to the steep slopes and difficult access at some parts of the reservoir and that a reasonable objective would be Scenario 2 that would achieve 80 percent clearing.

A post-flooding reservoir cleanup program extending over a period of a few years would be required even if the reservoir was completely

Table 5-1

Reservoir Clearing Costs
(M$)

Area (ha)		Scenario 1 (100%)	Scenario 2 (80%)	Scenario 3 (67%)	Scenario 4 (33%)
6 650	Initial clearing	16.16	12.93	10.83	5.33
	Post-flooding Cleanup	1.00	2.00	3.00	4.00
	Total	17.16	14.93	13.83	9.33
15 000	Initial clearing	36.45	29.16	24.42	12.03
	Post-flooding Cleanup	1.00	2.00	3.00	4.00
	Total	37.45	31.16	27.42	16.03

Note: These costs were calculated assuming 85 percent machine clearing and 15 percent hand clearing.

cleared. A lesser degree of initial clearing would require a greater amount of cleanup. Assuming an annual debris cleanup program of 2, 4, 6 and 8 years for Scenarios 1, 2, 3 and 4 at a cost of $500,000, the total cost would be $1.0, $2.0, $3.0 and $4.0 million. A certain amount of debris from the original reservoir would be picked up in the cleanup, however it has not been specifically allowed for.

For Scenario 2, the total clearing costs would therefore be $14,930,000 for 6650 ha and $31,160,000 for 15 000 ha.

Reservoir clearing would be the main project employment activity for the 3 to 5 years it is estimated to take. It is not known if sufficient resources exist in the Williston Lake area to accomplish the task in the time available. Local organizations should however, be given consideration for the tasks. Contracts and clearing packages could be designed to accommodate local groups. It may be that additional assistance such as advice on setting up companies, renting equipment, preparing bids and others would be required from Hydro. The possibility also exists of having the logging companies undertake additional cleanup when they are logging areas adjacent to the reservoir that would be flooded.

SECTION 6.0 - HERITAGE

6.1 DESCRIPTION

Little physical evidence is available to establish the actual length of human occupation of the Williston Lake area due to a lack of archaeological records. Nonetheless, ethnographic studies of the Athapaskan peoples, historical records at the time of early contact and archaeological evidence from sites downstream of the W.A.C. Bennett Dam and in the vicinity of Mt. Edziza to the west, suggest human occupation of portions of the Williston Lake basin during the last 5000 years.

(a) Prehistoric Period

It has generally been considered that the prehistory of aboriginal peoples in British Columbia commenced at the end of the last ice age about 10 000 years ago. Recent geological, palynological and archaeological studies suggest that the model of complete glaciation covering the total provincial land mass is incorrect. In fact, large tracts of land appear to have been ice-free during the most recent glacial period, (Loy 1981:10). Fladmark (1983) has suggested that the Peace River district remained ice-free during the late Wisconsinan glaciation, his theory being supported by a sequence of dates obtained from a pollen core found near Grande Prairie Alberta which lacked any stratigraphic evidence of glaciation. The sequence of dates obtained from the pollen core were >30 000; 17 570 ± 650; 12 650 ± 320; and 10 740 ± 395 B.P. (Before Present), (Fladmark 1983).

A number of ethnographers have suggested that the Sekani and Beaver peoples were forced into the upper Peace, Finlay and Parsnip river drainages during the early to mid-eighteenth

century as a result of pressure from the Cree, (Jenness 1937; McGhee 1963; VanStone 1974; Brody 1981). Cree, used by the early fur traders as porters, boatmen and guides obtained fire arms and drove the Beaver up towards the headwaters of the Peace. The Beaver also armed, in turn, drove the Sekani from the eastern foothills into the heights of the Rockies. The possibility also exists that the most recent pressure by the Cree was only the latest of a number of movements into and out of the Williston basin over a longer period of time (D. Burley, pers. comm.).

Prior to contact with the fur trade, the Sekani were considered to have utilized upland areas and lakes rather than river bottoms. This is understandable considering that the rivers flowed into the Arctic drainage and did not have the salmon runs characteristic of the Pacific drainage regions to be used for food. Rather they had to rely on wildlife, especially the larger animals which used the upland areas. At the time of contact, spruce bark canoes were used on the Parsnip River by the Sekani but there is some suggestion that overland travel was preferred, (Cassidy 1976). The difficulties in climate, geography and habitat affected the region's cultures such that "the Sekani became expert at the use of mountainous resources; while the Beaver specialized in the foothills and adjacent forests", (Brody 1981).

The Tahltan to the west of the subject area traded with the Sekani peoples profiting in the exchange of coastal goods obtained from the Tlingit for furs from the interior tribes, (Albright 1984). As well, sites located by Albright in the Metsantan Pass area are situated on a major trail linking the Finlay River with the Mt. Edziza area in the heart of the Stikine drainage area. These sites contain artifacts of both obsidian and basalt. Obsidian artifacts were also found by McGhee on the Ingenika River during his survey of the Portage Mountain Dam Reservoir (Williston Lake),

(McGhee 1963). Spurling (1976), reporting on his investigations in the Site C area suggests that prehistoric trade and exchange networks were revealed by the presence of artifacts made of obsidian at two sites within the survey area. Obsidian, which is a volcanic glass not found locally could have come from Mt. Edziza about 300 km west of Williston Lake. Fladmark and Nelson undertook a reconnaissance of the southwest portion of Mt. Edziza in 1977. A large number of quarry sites as well as associated workshops and campsites were found in several localities adjacent to extensive obsidian sources. Subsequent investigations of these sites indicates occupation and use of the area during the past 5000 years, (Fladmark 1982).

(b) Historic Period

As a result of research undertaken for the Site C project it was determined that three distinctive historical periods were represented for that area: The Fur Trade period between 1793 and 1860; the Gold Rush, Missionary, and Systematic Exploration period between 1860 and 1910; and the Agricultural Settlement period beginning about 1910, (Heritage Conservation Branch Blue Paper No. 7). These sequences also appear to be appropriate for the Williston Lake area. Historic occupation of the Williston Lake area was primarily adjacent to the major rivers which provided the main transportation routes. Consequently, historic remains such as Fort Grahame, will have been previously impacted by the initial impoundment of Williston Lake.

The Sekani people appear to fit into the community pattern defined by Beardsley (1956) as Restricted Wandering, or communities that wander about within a territory that they define as theirs and defend against trespass. Vanstone (1974) describes the Sekani as having a more exclusive concept of territoriality than most other

Athapaskans and frequently killed intruders. Jenness (1927) states that the Sekani of his day spent from November until mid-summer on the plateau and mountain slopes. The rest of the year, which is the poor hunting season, they fished in the small mountain lakes, (Jenness 1927). One member of the Ingenika River Band mentioned that his grandfather told him that the "old-time people" lived back in the mountains and did not go down into the valleys except when it was necessary (McGhee 1963).

6.2 HERITAGE RESOURCE IMPACTS

An archaeological survey was undertaken by McGhee (1963) in the area of Williston Lake. The area examined encompassed sections of the Parsnip and Finlay rivers as well as a short reconnaissance survey of the Peace River Valley between Gold Bar and the Finlay Forks.

Of 17 sites surveyed, 16 yielded what appeared to be prehistoric material. Most sites were found on the Ingenika and the Finlay rivers in the vicinity of the mouth of the Ingenika. Many of these sites were found close to, if not above the existing Williston Lake flood level, and in the area where the high plateau country approached the former river bottom or where the pine covered plateau dropped to the rivers in well defined terraces.

The findings of the 1963 archaeological survey suggest that very little material of archaeological interest existed in the valleys of the Parsnip and Finlay rivers below the El. 670.6 m or within the area flooded by Williston Lake.

It was felt that "the productive archaeological areas were probably back from the river valleys, on the plateau and on the slopes of

mountains", (McGhee 1963). This view is also supported by available ethnographic studies about the Sekani and Athapaskan Indians and historical reports from early fur traders.

The foregoing suggests the probability exists for impacts to prehistoric sites as the reservoir is raised beyond the existing full supply level. The available information indicates the inhabitants of the area favoured the benchlands over the valley bottoms and it is these benchlands that could be flooded. It must be noted however that flooding will be of a relatively short duration during the year.

SECTION 7.0 - RECREATION

7.1 DESCRIPTION

(a) Developed Recreation Sites

The majority of developed recreation sites in the Williston Lake region are provided by the Ministry of Forests and Lands. The developed shoreline sites on Williston Lake (Finlay Bay, Weston Creek, Six Mile Bay and Cut Thumb Bay), are located on the east side of Parsnip Reach. All of these sites offer minimal facilities and boat launching opportunities; Finlay Bay is the most developed and popular in this respect, attracting over 3400 users between May and November 1983. More recent estimates of use are not available.

Upland recreation sites provided by the Ministry of Forests and Lands are located adjacent to lakes, rivers and forest access roads primarily in the areas west and south of the Parsnip Reach.

B. C. Hydro's Mackenzie recreation area situated northwest of the community provides boater access to the Parsnip Reach and provides limited day use and overnight facilities. B. C. Hydro also operates a campground and day use area at Peace Canyon Park on Dinosaur Lake (Peace Canyon Reservoir). A public boat launch is provided at this site.

Dunlevy recreation area is the only provincial park on Williston Lake. The site offers a single boat launch ramp and picnic facilities. Between May and September 1983, 2679 parties (±9377 people) visited the site. In 1985, the same use period

attracted 1610 parties (±5635 people). The proportion of boaters represented in the yearly attendance figures has never been determined.

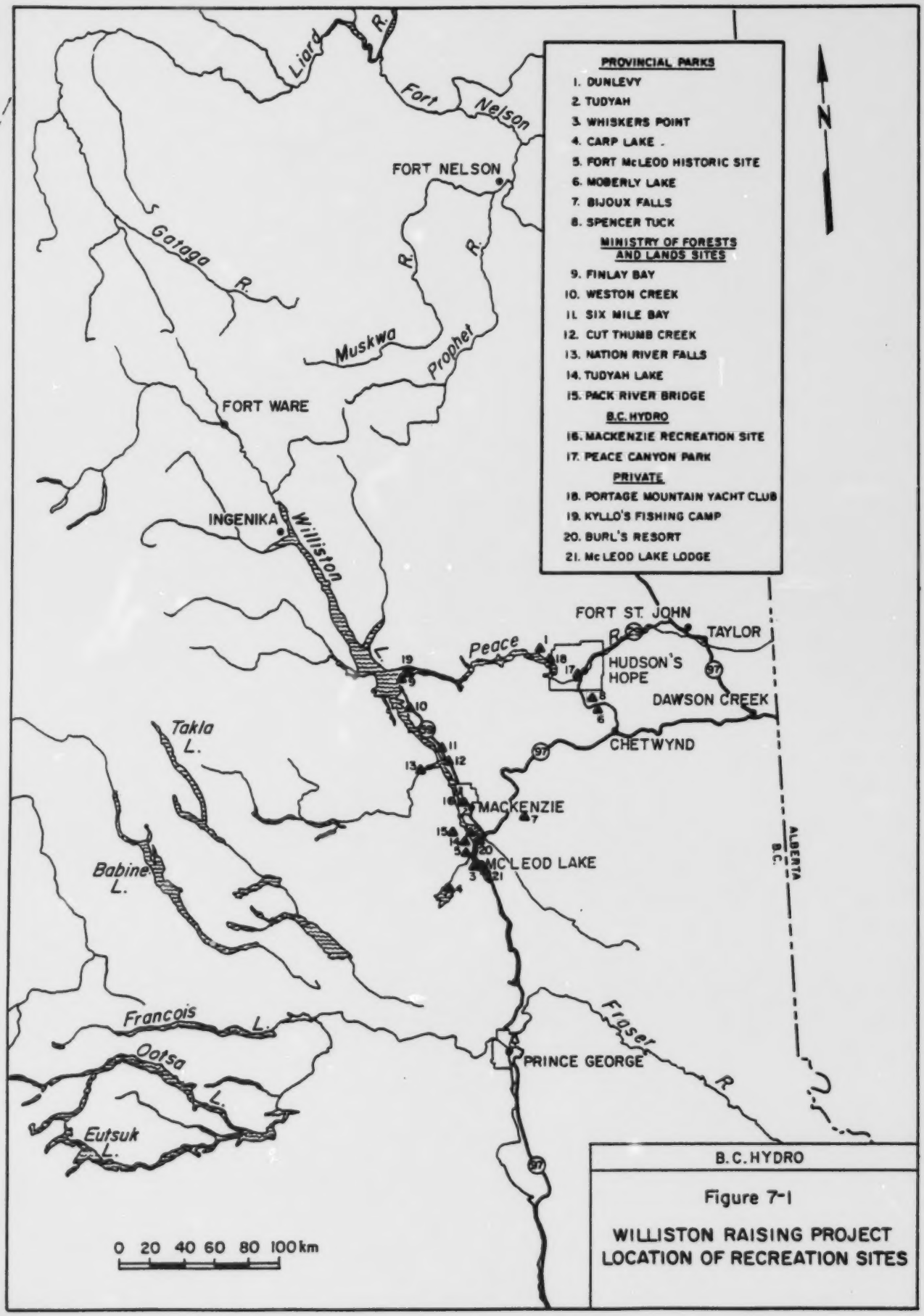
Tudyah Lake and Whiskers Point Class A provincial parks, located south of Parsnip Reach provide day use and overnight facilities. Five other provincial parks are located within a 60 km radius of Williston Lake; Carp Lake, Fort MacLeod Historic site, Moberly Lake, Bijoux Falls and Spencer Tuck. Use statistics are collected regularly for each site; monthly and annual totals are published by the Ministry of Environment and Parks.

A private marina developed by the Portage Mountain Yacht Club is located at Gravel Hill Creek near W.A.C. Bennett Dam. Moorage for about 50 boats is provided for club members. Boat launching for non-members is available for a fee.

Commercial recreation facilities on Williston Lake include Kyllo's Fishing Camp and Resort at Finlay Bay and a guiding lodge on the east shore of Davis Bay on Finlay Reach. Burl's Resort, offering cabins and canoe rentals operates on Tudyah Lake, while MacLeod Lake Lodge provides shorefront cabins and a boat launch ramp at its facility on MacLeod Lake.

(b) Recreation Use

The significant recreation resources of Williston Lake and the surrounding uplands are its sportfish and game populations. The Peace Reach, with minimal debris, a relatively deep navigation channel, angling opportunities and attractive scenery offers favourable boating and fishing conditions. The Finlay and Parsnip reaches in comparison offer less attractive recreation environments; large shallow areas, considerable amounts of debris, unpredictable winds and industrial traffic.



B.C. HYDRO

Figure 7-1

WILLISTON RAISING PROJECT
LOCATION OF RECREATION SITES

The development of forest access roads in the Williston region has created new opportunities for year-round land-based recreation activities. D. Coombes (1977) identified the potential for a variety of upland activities; hiking, camping, sightseeing, snowmobiling and skiing.

Previous studies (Macdonald 1981) concluded that the use of Williston Lake and surroundings for recreation is not intensive in spite of the expanding forestry road system and the ongoing debris clearing program on the reservoir. These studies cite as contributing factors the relatively small local and tourist populations, the lack of developed destination sites, the effects of the changing fishery resource, and the existence of other recreation sites and opportunities in the region.

The limited use of Williston Lake for recreational boating and related water-based outdoor pursuits has been attributed to the dangers of floating, standing and submerged wood debris, wind and wave hazards, and the remote and undeveloped nature of the lake. Boater access to the lake is frequently restricted in May and June due to low water elevations caused by reservoir operations. Shoreline wood debris can block boater access to and from sheltered bays.

The draft Resource Management Strategy for the Williston Basin prepared by the Ministry of the Environment in 1982 estimated that the reservoir attracted between 18 000 to 26 000 recreation user-days in 1974. Of this total, an estimated 3000 user-days were for sportfishing while hunting pursuits accounted for approximately 8000 user-days in the same year, the remainder being spread between various other recreational activities (Coombes 1977). The limited sample population and possible respondent bias limits the usefulness of these results, especially as the study is now dated 12 years.

(c) Recreation Development

The Ministry of Forests and Lands has identified a number of sites which receive regular public use but which lack developed facilities. An additional seven recreation sites are proposed for the Peace Arm to respond to existing use levels.

Ministry of Environment and Parks staff have indicated that the provincial park capacity in the Williston region exceeds the current demand for these facilities; thus, no new developments are projected for the foreseeable future.

The 1982 report by ELUC recommended a series of recreation development guidelines to emphasize cautious recreation development as a result of the natural and man-made hazards on the lake, adequate safety information and a development strategy which reflects public use patterns and debris conditions.

7.2 IMPACT ASSESSMENT

Considerable changes in the recreation resources of the region occurred when the three river valleys were flooded to create Williston Lake. The effects on recreation resources of a 1.5 m increase in the level of Williston Lake, some 20 years after the reservoir was first filled to capacity, will be much less significant when compared to this initial flooding.

The impacts of the raising project on upland recreation pursuits, such as hunting, camping or sight-seeing, will be indirect; resulting primarily from project impacts on forestry access roads and infrastructure, wildlife populations and reservoir clearing. The direct impacts of the project on recreation resources will be felt primarily

at shoreline locations which are the focus of a recreation population consisting predominantly of boaters and fishermen.

The proposed 1.5 m raising would totally inundate some of the existing shoreline recreation sites and informal use areas on Williston Lake. All of the primary public boat launch ramps (Mackenzie, Finlay and Dunlevy) and many of the undeveloped boater access points will be completely flooded at the proposed maximum normal reservoir elevation of 673.6 m. Other recreation sites, including those on Tudyah and MacLeod lakes, will suffer a reduction in the land available for recreational purposes. Ministry of Forests and Lands staff have indicated there are some locations where the proposed water level increase could encroach upon unique site features such as waterfalls and canyons and may reduce their potential and value for development.

The raising project may affect the lake sportfishery as a result of the reduction in spawning and rearing areas. This, in turn, may reduce the recreational use of the lake or result in less satisfying experience for those persons fishing. Similarly, project impacts on wildlife populations may affect the use of the region by hunters. (Refer to Sections 8.0 and 9.0 for further details on these topics.)

Cost effective mitigative measures would be implemented to minimize the negative impacts of the project on existing recreation resources. Remedial work could be undertaken to ensure the primary boat launch ramps remain usable at the full pool elevation of 673.6 m. In fact, a 1.5 m increase may mean that boater access to Williston Lake is available earlier in the year if higher water levels occur in late May and early June. Some of the Ministry of Forests and Lands shoreline recreation sites could be relocated to new locations which are better suited to the increased water levels.

Government agencies have expressed concern at preliminary project meetings that anything less than full clearing would have a negative

impact on their resources. There is no doubt that an increase in floating and submerged debris would reduce the value of the reservoir for recreation. The impacts of the project on bank stability, public safety, water quality and access may also detract from the recreational use of the lake. With high clearing standards and an ongoing maintenance program, however, the attractiveness of the reservoir for recreational use could be enhanced.

8.1 DESCRIPTION

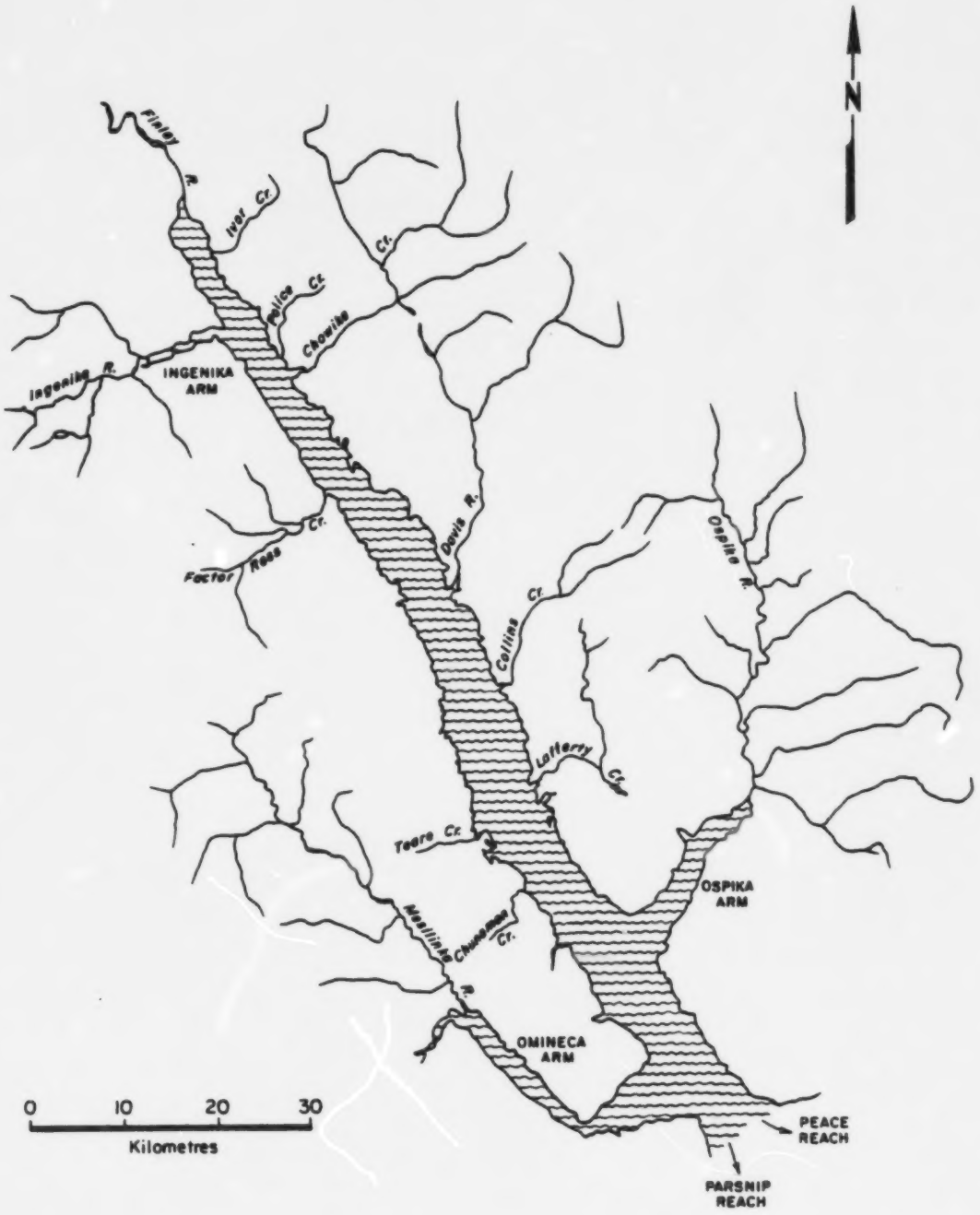
(a) Limnology and Water Quality

Since impoundment of Williston Reservoir (Figs. 8-1, 8-2 and 8-3) there has been little monitoring of the reservoir's stabilization. B. C. Research carried out some limnological studies over the period 1973 to 1976 with some additional work done in 1981 and 1982 by B. C. Hydro.

The estimated flushing rate in Williston Lake is about 2.2 years, (B. C. Research 1975) which combined with drawdown influences thermal stratification, patterns of dissolved oxygen and reduces the potential for normal lake processes to occur.

Under ice cover, no lake temperatures over 1.3°C were observed by B. C. Research (1975b). In natural lakes temperatures are near 0°C just under the ice increasing to about 4°C with depth. In Williston Lake the unusual winter temperature regime is most likely due to the low level drawing of water from the reservoir which breaks the normal inverse stratification. Delayed ice formation resulting from high winds or internal currents can also result in sub-normal temperature. B. C. Hydro, however, observed temperatures following the typical pattern under ice during April in 1981 and 1982.

Surface water temperatures in summer are rarely above 15°C (B. C. Research, 1975a). Thermal stratification develops over the period July to September and bottom water temperatures are not usually above 4°C in June. Thermoclines are weakly developed in the lake

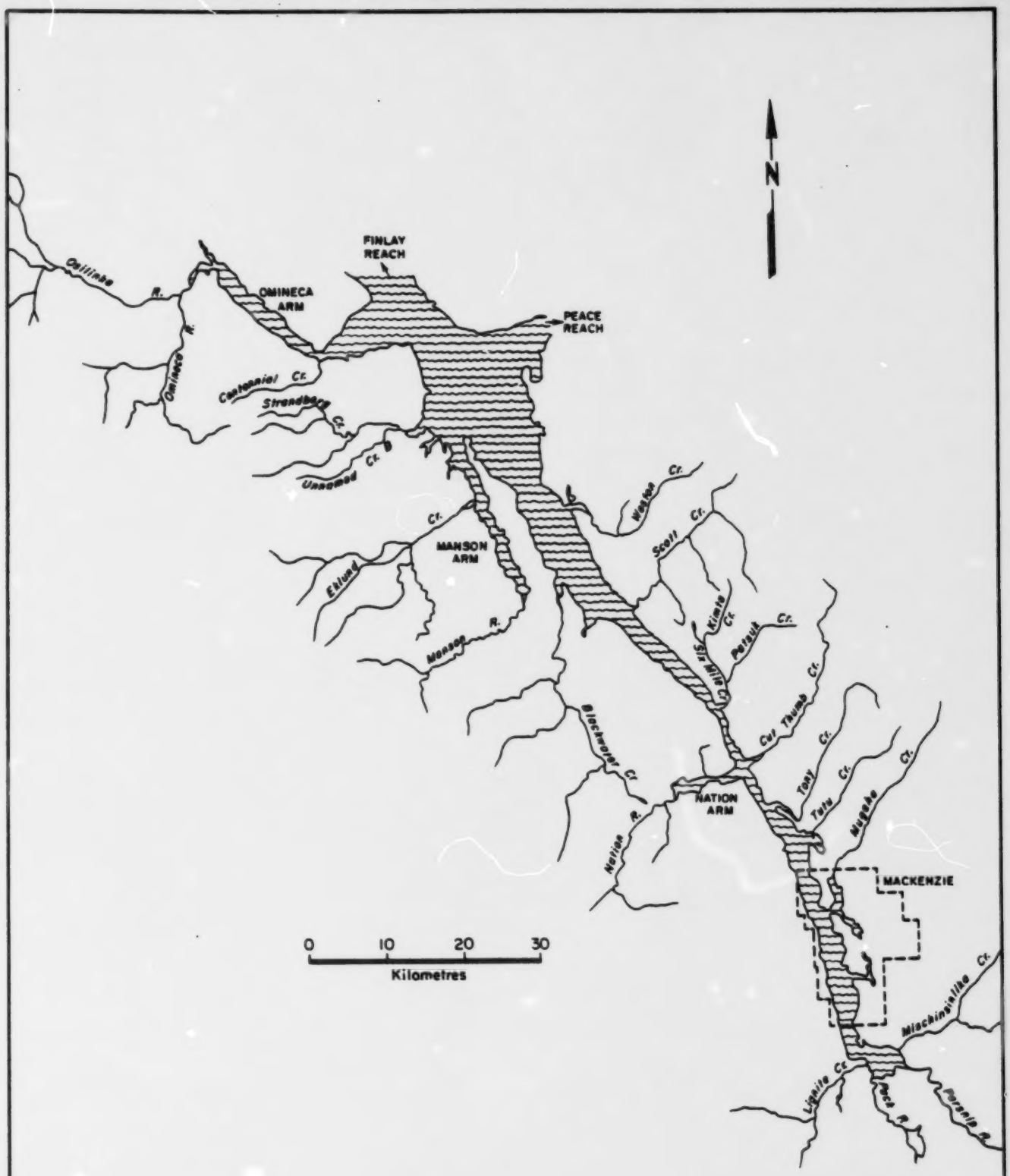


B.C. HYDRO

Figure 8-1

WILLISTON RAISING PROJECT

FINLAY REACH

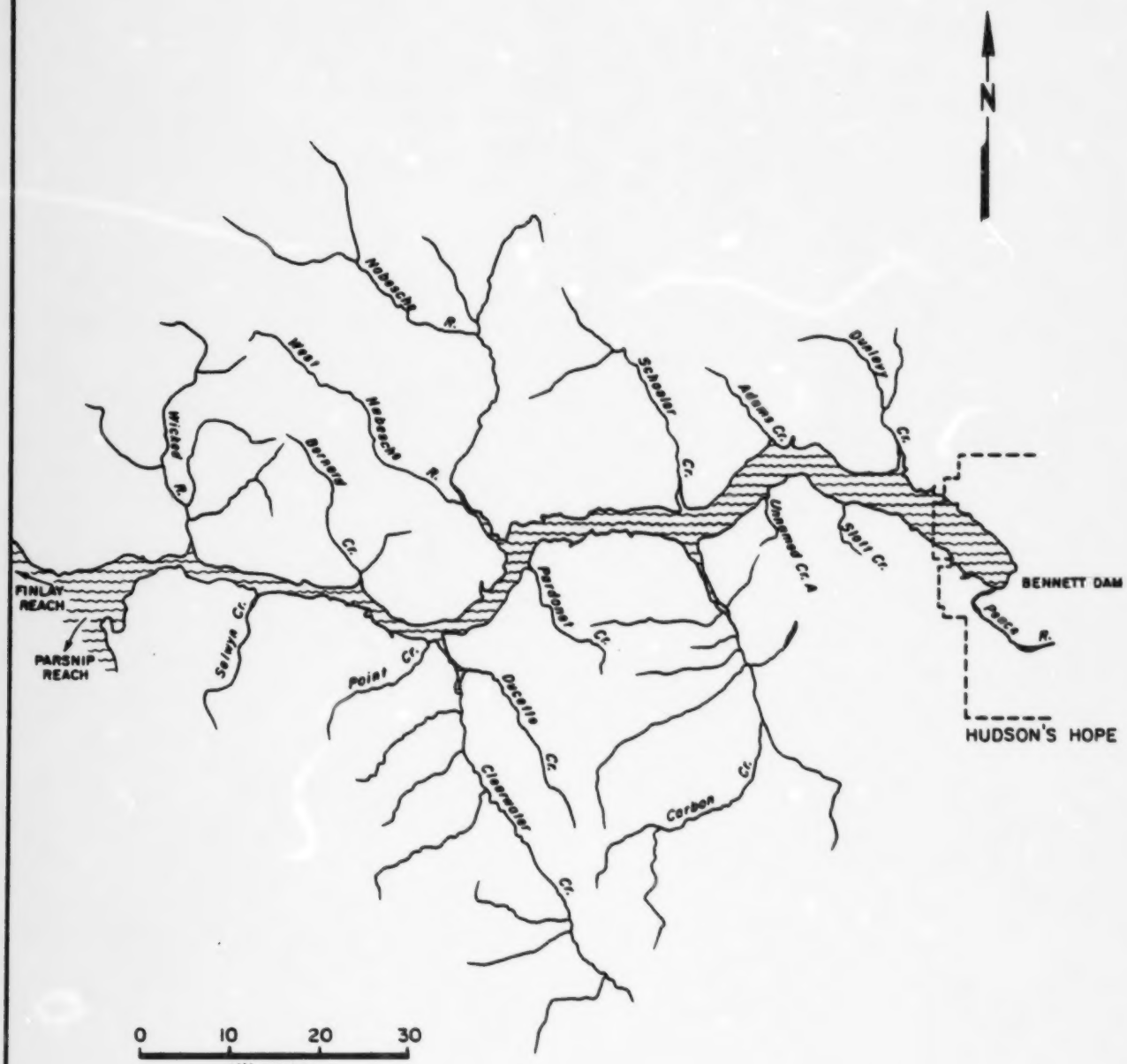


B.C. HYDRO

Figure 8-2

WILLISTON RAISING PROJECT

PARSNIP REACH



B.C. HYDRO

Figure 8-3

WILLISTON RAISING PROJECT
PEACE REACH

particularly in the Parsnip and Finlay reaches (B. C. Research 1975a; 1977). By November thermally stratified layers have disappeared under fall turnover conditions.

Dissolved oxygen levels vary with depth and season but are usually high and close to saturation (B. C. Research 1975a, 1975b, 1977). There has been no distinct or prolonged depletion of oxygen in bottom waters observed in Williston Lake for any season which is indicative of low to negligible transfer of nutrients from bottom sediments. Although this limits productivity in the reservoir, it does provide a habitat in which aquatic life can survive at all water depths.

Often major changes occur in an impoundment after filling usually coupled with increased nutrient loadings from soil erosion and decomposition of flooded vegetation. Results of the limited limnological studies carried out since impoundment indicate, however, that no such major changes are occurring in Williston Lake. Chemical and physical characteristics of Williston Lake are of high quality within all reaches, depths and seasons. Heavy metals of potential concern are not present in significant concentrations.

Williston Lake is classified as nutrient poor or oligotrophic (ELUC 1980; B. C. Research 1974; 1975a; 1975b; 1977). Nitrogen and phosphorus nutrient compounds are low in all seasons and the water is slightly alkaline with low to moderate hardness and total dissolved solids. Given that Williston Lake has such high water quality and cooler water temperatures with high dissolved oxygen it is apparent that biological activity is low, particularly at deeper depths (B. C. Research 1975b). Nutrient releases from biological activity from bottom deposits is also minimized by the relatively high rate of water replacement (B. C. Research 1975b). Stabilization or "aging" processes within the reservoir are taking

place slowly with negligible impacts on water quality. B. C. Research (1975b) predicted that the prevailing high water quality conditions would continue to the end of the stabilization period. Data collected some years later by B. C. Hydro substantiates this prediction.

The shoreline of Williston Lake is essentially abiotic due to seasonal fluctuations in reservoir operating levels. The area between the high and low water marks has an absence of aquatic vegetation and invertebrates which are found in this normally productive region of natural lakes. Grinding action of debris and ice also limits littoral productivity. The most important factors reducing shoreline productivity are the exposure of substrates for long periods of time during drawdown and rapid changes in water levels precluding colonization by littoral species (ELUC 1980).

(b) Reservoir Fishery

The Ministry of Environment (Barrett and Halsey 1985) is the principal group to have carried out fish inventory work on Williston Lake since impoundment. A total of 14 species of fish were collected during their work in 1974 and 1975. Major species found at most locations in the three main reaches included: lake and mountain whitefish, Dolly Varden, Arctic grayling, rainbow trout and kokanee. Generally there was little difference in the species recorded in the system prior to flooding (Withler 1959) compared to those collected in 1974/75 (Barrett and Halsey 1985). Lake trout was not captured in the later studies although it has been found in the southern Parsnip drainage. Fluctuating water levels are probably the main limiting factors to lake trout production as they utilize near shore areas for spawning.

Total catches were smaller in the Finlay Reach compared with the Parsnip and Peace reaches. The most predominant species was lake

whitefish in all reaches with the greatest numbers being captured in the Peace Reach. Their predominance may be a reflection of their ability to take better advantage of the new lacustrine habitat (Barrett and Halsey 1985). Longnose suckers, rainbow trout and Dolly Varden were more predominant in the Finlay Basin which may be due to their ability to utilize the higher proportion of littoral habitat (Barrett and Halsey 1985). These investigations postulated that lake whitefish populations have probably "exploded" in response to the new reservoir environment.

The subject of permitting a commercial whitefish fishery in Williston Lake has arisen a number of times (D. Abelson, J. Hammond, pers. comm.). Abelson (pers. comm.) has indicated that such a fishery would not be permitted until the recreational sports fishery is adequately managed to meet the demands of anglers. He also added that appreciably more effort would be required in order to assess the feasibility of implementing a commercial fishery for the species.

These investigations postulated that kokanee were present in each of the reaches. The species has been reported to occur in Arctic Lake and current theories suggest that they have probably invaded the reservoir via the Parsnip River (Barrett and Halsey 1985; D. Abelson and J. Hammond, pers. comm.). Barrett and Halsey (1985) suggested that kokanee could become established over a wide area in Williston Lake serving as a source of prey for other sportfish such as rainbow trout, Dolly Varden and burbot. Hammond's (pers. comm.) information seems to support this theory as he indicated that kokanee numbers have risen appreciably since flooding. Kokanee have even been observed in Dinosaur Lake below W.A.C. Bennett Dam and downstream of Peace Canyon Dam in the Peace River (Abelson, Hammond, pers. comm.).

The Parsnip Reach contained a greater number of peamouth chub and squawfish than either the Finlay or Peace reaches (Barrett and Halsey 1985). McPhail and Lindsey (1970) reported that these species were at the northern limits of their geographic range in the Parsnip River. Their presence in the Finlay and Peace reaches suggests they are gradually colonizing these areas (Barrett and Halsey 1985).

The Finlay and Peace reaches seem to offer the best opportunities for recreational angling since the composition of sportfish is about three times (30% versus 10%) greater than in the Parsnip Reach. There are no quantitative data on recreational angling efforts and attendant success. The lake is frequented by anglers and they appear to have reasonable success in obtaining sportfish. Recreational angling is apparently popular at the mouths of tributaries although access has been a problem in the past due to floating debris. Calculation of sustained sportfish was estimated at 0.49 kg/ha or about 26 percent of the total which is a favourable proportion of the total yield for sustaining recreational fisheries. Accepting these calculations and the baseline data used in their development as accurate Barrett and Halsey (1985) felt that the sportfishery harvest could withstand considerable expansion.

According to Abelson (pers. comm.) production for rainbow trout and grayling is low in Williston Lake whereas significant numbers existed prior to flooding. Dolly Varden appear to be maintaining their numbers although larger members of the population seem to be decreasing in number. Abelson (pers. comm.) also feels the lake does not contribute significantly to sportfish production.

Abelson and Hammond (pers. comm.) indicated that fish inventory data need to be gathered on Williston Lake. Budget limitations have precluded such studies and consequently there are few data on

the present fisheries resources of Williston Lake. The lack of resource inventory studies may also be related to the fact that a compensation agreement between the Ministry and B. C. Hydro has yet to be finalized for the lake. The Ministry of Environment and Parks is planning to submit a proposal on what can be done regarding the fishing on Williston Lake (Abelson, pers. comm.).

(c) Tributary Fishery

The most comprehensive data collected on fish populations in Williston Lake tributaries are those carried out by the Ministry of Environment (Fisheries Branch) in 1975 (Bruce and Starr 1985). Prior to impoundment, the Parsnip, Finlay and Peace rivers as well as their tributaries supported populations of typical riverine species (Withler 1959). While impoundment may have increased the amount of water available to fish, the amount of important stream habitat decreased (Bruce and Starr 1985).

The Parsnip Reach contains the greatest number of streams and major river systems while the Finlay Reach has a lower number of streams compared with the Peace Reach but has more major systems (Bruce and Starr 1985). A total of 58 streams were surveyed; 30 from the Parsnip Reach, 13 from the Finlay Reach and, 15 from the Peace Reach.

Streams on the east side of Parsnip Reach lost large amounts of highly productive spawning, rearing and over-wintering habitat. Larger rivers such as the Parsnip, Pack, Nation, Manson and Omineca seem to have been less affected by impoundment (Bruce and Starr 1985).

Stream gradients on the east sides are low (2%) near the mouth but steeper (4% to 7%) where they emerge from the mountains. Streams on the west side are not as steep as those on the east (1% to 2%)

and are characterized by long runs of relatively low slope (1% to 2%) whereas headwaters are initially quite steep (10% to 15%).

Rainbow trout and Arctic grayling utilize streams on the east side. Rainbow trout move back into Williston Lake shortly after spawning while Arctic grayling remain in tributaries throughout the summer. Mountain whitefish, longnose suckers, squawfish and other coarse fish also reside in these streams.

Streams on the west side of the reach appear to be more productive than those on the east side which is likely due to the long sections of low gradient habitat. Rainbow trout, Arctic grayling, mountain whitefish and Dolly Varden were found in streams on the west side. Fry rearing habitat in the west side streams is more abundant.

All the larger rivers have low slopes (<1%) for extended distances and no major obstacles to fish movements (Bruce and Starr 1985). The major rivers such as the Parsnip, Pack, Nation, Manson and Omineca have good habitat for all age classes of all species. Over-wintering habitat was prevalent at most sites with spawning and rearing habitat observed in almost every reach (Bruce and Starr 1985).

According to Bruce and Starr (1985) fishing pressure is greatest on tributaries of the Parsnip Reach due to accessibility. They indicate that angling appears to keep fish populations depressed. Illegal fishing and general non-compliance with angling regulations also have negative effects on fish population levels. Rainbow trout and Arctic grayling are the most sensitive species in the reach although large Dolly Varden near creek mouths are susceptible to overexploitation.

Many of the low gradient reaches of tributaries in the Finlay Reach were flooded by the formation of Williston Lake. Streams on the east side north of Lafferty Creek have steep gradient in their lower reaches. Suckers were observed in the lower spectrum of low gradient streams. Arctic grayling were also present in these streams and likely utilize them for spawning and rearing (Bruce and Starr 1985). Mountain whitefish, rainbow and Dolly Varden were also captured. The latter species seemed to prefer steep gradient areas.

The Ospika River is the largest river on the east side of the reach and appeared to have good potential for spawning and rearing. Arctic grayling, Dolly Varden and mountain whitefish were observed in the Ospika River.

The Mesilinka and Ingenika rivers on the west side have high spawning and rearing potential which seems to be due to their low gradients (1% or less). Arctic grayling, mountain whitefish, Dolly Varden and lake whitefish were captured in the Ingenika. This river was the only other system besides the Pack and Parsnip where adult lake whitefish were collected. Smaller streams had little substrate suitable for spawning and rearing and no fish were collected.

The Finlay River seems to be very important in the sustenance of Williston Lake fish stocks. The river contains spawning and rearing habitat for a number of species including Dolly Varden, Arctic grayling, rainbow trout and mountain whitefish (Bruce and Starr 1985).

Sportfishing pressure is greatest on the east side of the basin, primarily for large Dolly Varden. The native Indians at Ingenika carry out subsistence fishing although the extent of the fishery

is unknown (D. Abelson, pers. comm.). Fishing seems to be confined to tributary mouths.

Sportfishing success seems to be still reasonable for Dolly Varden, rainbow trout and Arctic grayling (Flood, pers. comm.). Approximately 75 fish were captured near the end of August, 1986 in the vicinity of the Ingenika River with moderate fishing effort. Of the 31 fish kept, 20 were Dolly Varden ranging in weight from 0.45 kg to 2.27 kg and in length from 406 mm to 736 mm. Bruce and Starr (1985) indicate that fishing pressure for Dolly Varden is greatest and could be ultimately detrimental to the population.

Streams in the Peace Reach tend to be shorter and steeper than those in the Parsnip and Finlay reaches. Extensive low gradient areas were observed in some of the major tributaries including Nabesche, Clearwater and Carbon. Dunlevy Creek seemed to be the only medium-sized stream surveyed that had high spawning and rearing potential (Bruce and Starr 1985).

Dolly Varden appear to only utilize the larger watercourses such as the Nabesche River, Clearwater Creek and possibly Carbon Creek. Bruce and Starr (1985) observed Dolly Varden in spawning condition in the Nabesche River and smaller individuals at selected locations.

Rainbow trout were only found in Dunlevy and Schooler creeks as well as the Nabesche River. Mountain whitefish were observed throughout the Peace Reach and were collected in a few of the tributaries. Arctic grayling were the most common species encountered and were found to be utilizing spawning and rearing habitat in most of the tributaries.

Sportfishing effort is high in the Peace Reach and access is quite good to creek mouths. Boat launching facilities are present at the east and west ends of the Reach and at Dunlevy Creek.

(d) Mercury Levels in Fish

Mercury in the aquatic environment is derived from several sources. Industrial pollution was thought to be the prime source prior to the 1970s. More recently, however, it has become apparent that natural sources exist as well. Studies in Missouri (Koirtyohann et al. 1974), Saskatchewan (Wobeser et al. 1970) and Sweden (Johnels et al. 1967) have shown that high levels of mercury can occur in unpolluted lakes and rivers.

Research on reservoirs carried out in Labrador (Bruce and Spencer 1979), Northern Manitoba (Bodaly et al. 1984) and Southern Saskatchewan (Waite et al. 1980) confirmed that levels of mercury in fish can become elevated in isolation from industrial sources. These studies also found that fish from newly created reservoirs have increased levels of mercury above background levels indicating the flooding of land has resulted in the release of additional mercury into the system.

Mercury in newly created reservoirs is freed from inundated soils by the process of bacterial methylization. Decomposition of organics on the reservoir bottom results in elevated concentrations of bacteria which release methyl mercury from the substrate as part of their metabolic process.

Williston Reservoir is located in a geographical area which has relatively high mercury levels compared to elsewhere in B. C. (Garrett et al. 1978). Based on this knowledge and the fact that new reservoirs have been found to develop elevated levels of mercury in aquatic organisms, Health and Welfare (1978, 1979, 1980 and 1981) have monitored levels in fish and in local residents who rely on fish as a major component of their diet. Results show

that among sportfish, Dolly Varden are the only species with individuals exceeding the recommended levels for human consumption (0.5 µg of mercury per gram of fish). Some Dolly Varden from the Finlay River exhibited mercury levels that should be of concern to persons eating these fish as a regular part of their diet; however, for persons eating these fish occasionally there is considerably less concern. Mercury in rainbow trout was found to be below the recommended concentration and it is considered that fish at lower trophic levels, such as kokanee, would exhibit even lower concentrations.

The influence of the creation of Williston Reservoir on mercury levels in fish is unknown. It is reasonable to assume that high natural levels existed prior to reservoir development based on existing high levels in fish from the nearby Pinchi Lake area and in the Finlay River stocks of Dolly Varden. However, creation of Williston Reservoir may have contributed to an increased level of mercury in fish as a result of inundation of large areas and the subsequent decomposition of organic matter.

8.2 IMPACT ASSESSMENT

(a) Limnology and Water Quality

Increasing the water level of Williston Lake an additional 1.5 m would initiate further erosion of the shoreline resulting in additional materials entering the reservoir. Eroded shoreline materials could eventually be deposited within the reservoir but exact locations are difficult to predict given the lack of knowledge on existing morphometry and water currents.

Increased water levels may reduce the flushing rate of the reservoir. This could result in better developed thermal profiles which may affect chemical and physical parameters such as

dissolved oxygen and internal currents. Also with the lower flushing rate oxygen depletion may be more prevalent particularly in the late summer when thermal stratification is more developed. The extent to which bottom waters might become depleted is unknown but they would likely not develop anoxic conditions.

Increased suspended sediments from shoreline erosion would reduce light penetration and hence productivity. Primary productivity is already limited to shallow subsurface waters in the lake (B. C. Research 1977) due to reduced light transmission. Some reduction in absolute productivity values can be expected in the lake and would likely continue until the shoreline is stabilized.

Incremental flooding of shoreline soils and vegetation would also leach soluable materials including nutrients from the inundated substrates. Should the amounts of the soluble materials be relatively small, insignificant changes in water quality would likely occur. In the case of Williston Lake, there would be between 6650 ha and 15 000 ha of shoreline flooded. This represents a minor incremental increase in surface area of the reservoir. Although the absolute amounts of soluble materials entering the reservoir may be great they are not likely to have profound effects on water quality. Initial flooding over a much greater area, for example, did not appear to affect the general good water quality prior to impoundment (B. C. Research 1977).

Decomposition of inundated vegetation is expected to progress at a very low rate. Inundation would only occur at high water and for only part of the year. As the vegetation dies and decomposes some of it may enter the reservoir as floating debris ultimately settling on the bottom of the lake. Further decomposition on the lake bottom would also occur very slowly.

A "pulse" increase in mercury concentrations could result from flooding shoreline soils and vegetation. As discussed earlier inundated soils seem to be the source of elevated mercury levels

in fish from new impoundments. Changes in the mercury concentration in water are difficult to detect due to limitations in analytical procedures. This should be considered when developing study programs for the next level of investigation.

Williston lake is a cold, oligotrophic lake and consequently its aging or stabilization processes are likely progressing at very low rates. Incrementally raising the reservoir 1.5 m will lengthen the ultimate stabilization period. It is difficult to predict how long stabilization might take, although a reasonable time frame would appear to be several decades.

(b) Reservoir Fishery

Raising Williston Lake 1.5 m would marginally increase the amount of habitat for fish more suited to lake environments. There is a perception that flooding of Williston Lake led to an "explosion" in fish populations. There is no quantifiable or supportable evidence to substantiate this claim. Water quality and limnological studies carried out detected no major nutrient loading in Williston Lake. Data, in fact, classify the lake as oligotrophic with water quality parameters closely resembling those of pre-impoundment levels. It is conceivable that any small initial increases in nutrients were quickly tied up in primary and secondary production.

Existing fisheries resources in Williston lake are undoubtedly reflective of changes that occurred from the initial flooding. This has principally permitted populations of lake whitefish to increase. Incrementally raising the lake another 1.5 m may prove to be even more conducive to establishment of a large whitefish fishery resource in the lake. The presence of other more riverine species such as Dolly Varden should continue although their numbers would ultimately be more dependent on impacts to tributaries resulting from inundation.

Fish would probably be more affected by suspended sediment loadings and resulting productivity changes than by increased nutrient loadings. If secondary productivity is reduced by increased turbidity the forage base for lake and mountain whitefishes as well as kokanee could be reduced.

(c) Tributary Fishery

Considerable spawning and rearing habitat was lost in tributaries from initial flooding. Bruce and Starr (1985) estimate there is about 505 km, 260 km, and 65 km of potential spawning habitat in tributaries of the Parsnip, Finlay and Peace reaches.

Accessibility to tributaries at low water would not be affected by the present proposal. Higher water levels may facilitate access to the upper portions of some tributaries. Some fish could spawn in new habitat made available by the higher water levels and these eggs could be killed if the reservoir level drops before hatching. This is particularly the case in the Peace Reach where most streams enter the reservoir through a canyon. Access, however, is not the only consideration as adequate spawning and rearing habitat are prerequisites to sustaining fisheries resources in both the tributaries and reservoir.

Tributaries of the Peace Reach are generally much shorter in length and steeper than those in the other two reaches. Raising Williston Lake 1.5 m could result in some loss of the limited spawning and rearing habitat. Tributaries of the Peace Reach primarily support game fish (Arctic grayling, Dolly Varden, rainbow trout), loss of suitable habitat for these species could impact on the structure of fish populations in the Peace Reach.

Abundant spawning habitat exists in tributaries of the Parsnip and Finlay reaches. Small and medium sized streams with low gradients (0.5% to 2%) in these reaches are important for juvenile rearing. A 1.5 m raising could result in the loss of a large proportion of

the streams given their low gradients, however appreciable spawning and rearing habitat would remain. Quantifying the possible extent of habitat loss cannot be accomplished with existing map products. Large streams in these reaches provide much greater habitat for juvenile rearing and is enhanced by low gradients. Raising the level of the larger, low gradient streams in their lower reaches could provide additional habitat for lake whitefish. The species was only observed in the larger tributaries of the Parsnip and Finlay reaches and some tributary resident populations are believed to already exist.

Should access be improved by a 1.5 m raising there could be additional fishing pressure placed on tributaries. Earlier assessments have regarded fishing pressure and general non-compliance with angling regulations as the main negative influences on tributary fish stocks.

SECTION 9.0 - WILDLIFE

9.1 DESCRIPTION

The best available description of the wildlife resources surrounding the Williston Reservoir is Bonar (1975) based on an assessment done in 1974/75. The specific methodology as to the frequency of ground control versus visual assessment from the air and map interpretation is not stated. Appendix B summarizes his description of the general wildlife value of specific areas located near creeks, mountains or other landmarks. These areas are presented in an order which circumscribes the Parsnip and Finlay reaches clockwise from Pack River; and then moves west to east down the Peace Reach from Finlay Forks to Peace Canyon. This review and summarization makes no attempt to update Bonar's information by speculating on successional change that may have occurred since his analysis. Bonar stated that land use decisions based on value of habitat "reflect the actual situation in resource conflicts between wildlife and other activities".

The inherent capability of the land to support ungulates is the standard measure of habitat quality used by the Wildlife Branch. The degree of limitation of the land to produce wildlife determines the capability class. Briefly summarized the level of limitation for each class are:

Class 1 - none significant
Class 2 - very slight
Class 3 - slight
Class 4 - moderate
Class 5 - moderately severe
Class 6 - severe
Class 7 - no production

Common limitations are climatic (aridity, climate, snow depth, exposure) or physiographic (fertility, land form, inundation, soil moisture, adverse soil characteristics, soil depth, adverse topography). The first three classes have a special designation "W" which denotes land which are winter ranges upon which animals from the surrounding areas depend for over-winter survival.

Ungulate capability maps (Canada Land Inventory 1970a) of the Finlay and Parsnip reaches show that the area surrounding the Williston Lake is a combination of 60 to 80 percent Class 4 capability and 20 to 40 percent Class 3W for moose. The biophysical limitation for most of this land relates to excessive snow depths. The Peace Reach east of the Nabesche River is classified as Class 1W, lands with no significant limitations to the production of moose and deer. West of the Nabesche the steep and rugged terrain is Class 5, with moderately severe limitations to the production of moose and caribou.

Elk herds occur at three locations near the reservoir (Bonar 1975, Harper, pers. comm.). The largest herd occupies the triangle between Ingenika Arm and the northern extreme of the Finlay Reach. Another herd utilizes the area southeast of Ospika Arm. A small herd frequents the Dunlevy Creek area near the site where 107 elk were transplanted in the winter of 1984/85. A fourth herd may occur in the area east of the Parsnip Reach between Cut Thumb Creek and Scott Creek (Fish and Wildlife Branch 1981). Elk in small numbers may also occur in many scattered pockets along the north shore of the Peace Reach or along the Finlay and Parsnip reaches.

Mule deer are fairly plentiful on the open slopes north of the Peace Reach and in lesser numbers south of the reservoir. Other herds have been reported along the lower Nation River, the Omineca River and the Ingenika Valley (Bonar 1975). White-tailed deer have been observed in riparian habitats along the major tributaries to the Peace River (Ministry of Environment 1981).

Caribou, mountain goat and Stone's sheep occur in numerous alpine zones. Locations where there is potential for impact have been identified in Appendix B.

Black and grizzly bear are abundant over the entire area. Carnivores and furbearing rodents which are important in the fur harvest, in order of relative value (Wildlife Branch 1985) to the Management Units affected are:

Species	Value (1984/85)	Percent
Marten	$ 73,767	66.8
Lynx	24,198	21.9
Beaver	3,105	2.8
Mink	2,087	1.9
Coyote	2,086	1.9
Fisher	1,996	1.8
Fox	753	0.7
Squirrel	673	0.6
Wolverine	431	0.4
Otter	419	0.4
Wolf	413	0.4
Weasel	354	0.3
Muskrat	119	0.1
Total	$110,401	100.0

The proportion of these catches taken along the reservoir perimeter is not known but could be determined by interviewing the trappers. The values recorded may not include Indian trappers who were not required to register their trapline harvest.

Waterfowl are not abundant on or around the reservoir. Canada geese are most common on the tributary streams where they nest (Bonar 1975). Small potholes and shallow bays of Williston Lake harbour mallard, widgeon, teal and pintail. Some loons and grebes nest on the reservoir. Other waterfowl use the area during spring and fall migration. Overall, the reservoir area has a low capability for the production of waterfowl (Canada Land Inventory 1970b).

Two raptor species occur in large numbers around the reservoir. Bald eagles and osprey both nest near the water because fish is so important to their diet. Other raptors, red-tailed hawk, goshawks, kestrel, etc. use the surrounding areas.

Moose is the ungulate most likely to be affected by the Williston raising; therefore, an examination of the historical and current moose-hunter use patterns (Fish and Wildlife Branch 1976 to 1985) was undertaken. The potential zone of impact was defined as all Management Units (MUs, see Fig. 9-4) touching on the existing reservoir (729, 730, 731, 735, 736, 737, 738, 740 and 741). Cumulatively, these MUs constitute 16.4 percent of the area of Wildlife Management Region 7. The average (1976 to 1985) proportional contribution of hunters (11.1%), harvest (9.7%) and hunter-days (9.0%) are all less than 16.4 percent expected on an areal basis (Fig. 9-1).

Hunter success in the affected MUs is still considerably better than the Provincial or Regional values. No trend of decline is evident in the smaller unit but is weakly visible in the Region and to 1983 was strongly evident in the Province as a whole. This graph does not tell us what the potential for Williston Lake was before flooding and does not preclude the possibility that moose numbers dropped (or rose) since construction of the dam in 1968. Hunter success in the affected area certainly shows instability compared to the Region or Province, a factor which may be caused by broader population fluctuation with reduced winter range as a contributor. Notice the marked correlation in success declines in 1979 and 1983. This correlation suggests a province-wide phenomenon, such as a harsh winter which reduced over-winter survival everywhere.

Moose harvest based on resident hunter statistics in the affected MUs has been highly variable, dropping from a high level of 668 moose in 1976 to a low of 444 in 1979 (Fig. 9-2). This decline in success may have contributed to a marked drop in the number of hunters returning in

Figure 9-1

CONTRIBUTION OF WILLISTON MU'S ON REGIONAL MOOSE STATISTICS

BY AREA $\frac{\text{AFFECTED MU'S}}{\text{REGION}}$ = 16.4%

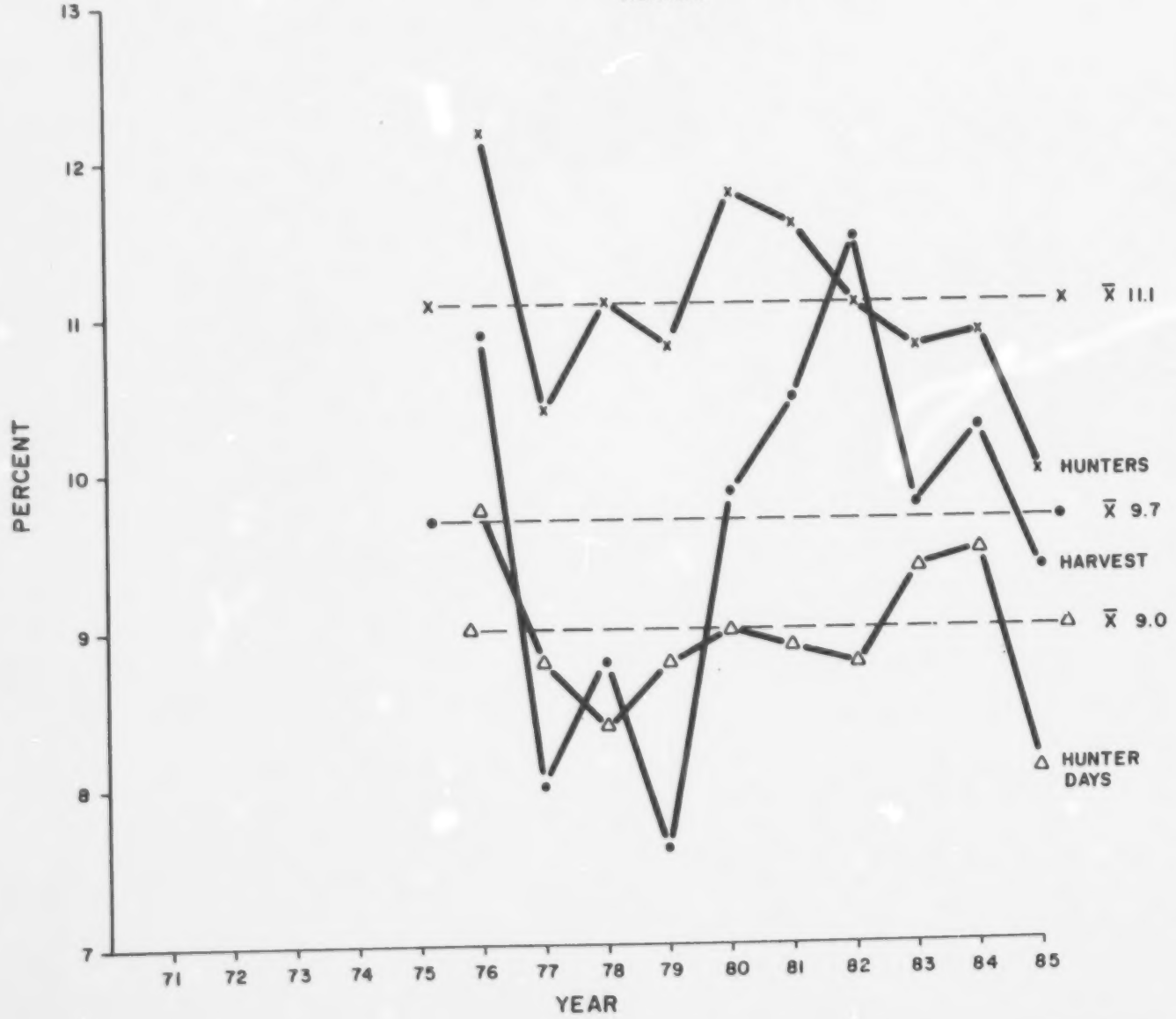
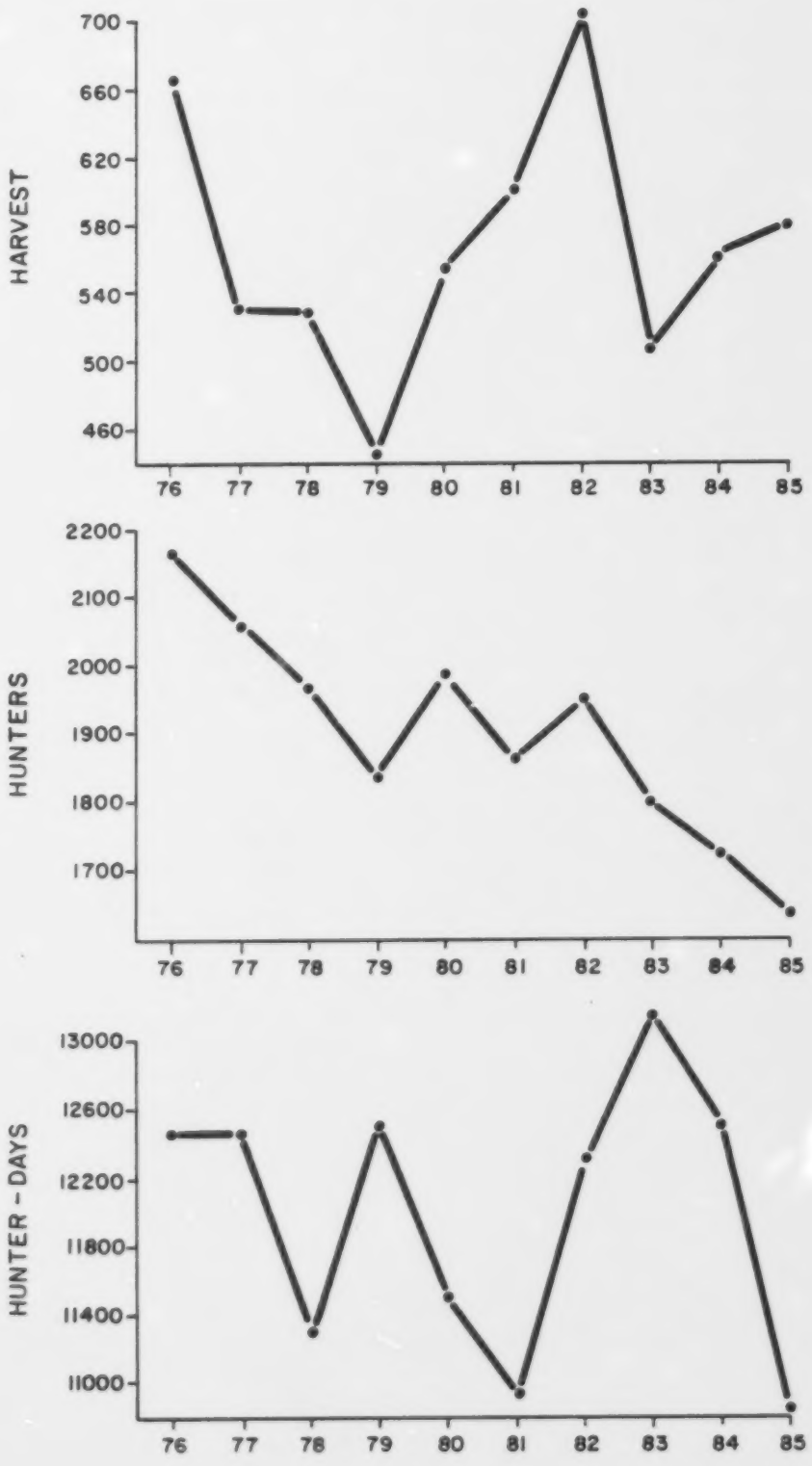


Figure 9-2
MOOSE HUNTING STATISTICS FOR MANAGEMENT UNITS
POTENTIALLY AFFECTED BY RESERVOIR RAISING



subsequent years, although provincial economics, climate, and new road access may have also contributed. From 1979 to 1982 the harvest recovers to the 1976 level but the number of hunters continues to plummet. This phenomenon is probably a result of a dramatically changed management philosophy in 1980 and 1981 which altered the hunting pressure onto the more abundant immature bulls and calves. Fewer hunters spent more days hunting in the 1982 to 1984 period but once again harvest dropped off.

Guide-outfitters operating in British Columbia file an annual declaration of hunting activities of non-resident hunters but this submission does not include the number of hunter-days. The number of guided hunters in the area remained quite stable from 1971 to 1980 (Ministry of Environment 1983). The number of hunter-days, estimated at 10 days per guided hunter, amounts to about 15 percent of resident hunter activity. Moose are the most frequently harvested species followed by goat, caribou, sheep, black bear, grizzly bear and elk (1975 to 1980 data).

Provincially, in the past 16 years, one in every 3.4 hunters has successfully taken home a moose. The ratio in the MUs affected by Williston has averaged exactly the same in the 10 years for which data are available. Region 7 has consistently provided a better hunter success than the provincial average as one in every 2.7 hunters have bagged their quarry. While the trend for both the province and the region has been one of decreasing success, that of the affected MUs has been improving over time.

The provincial wildlife management objectives (Fish and Wildlife Branch 1979) use another measure of hunter success in setting objectives. The provincial objective for moose is the provision of 600 000 sport-hunting days of recreation and an annual sustained hunter kill of 30 000 animals. Therefore their goal is one moose harvested for every 20 days spent hunting. The provincial success for 1976 to

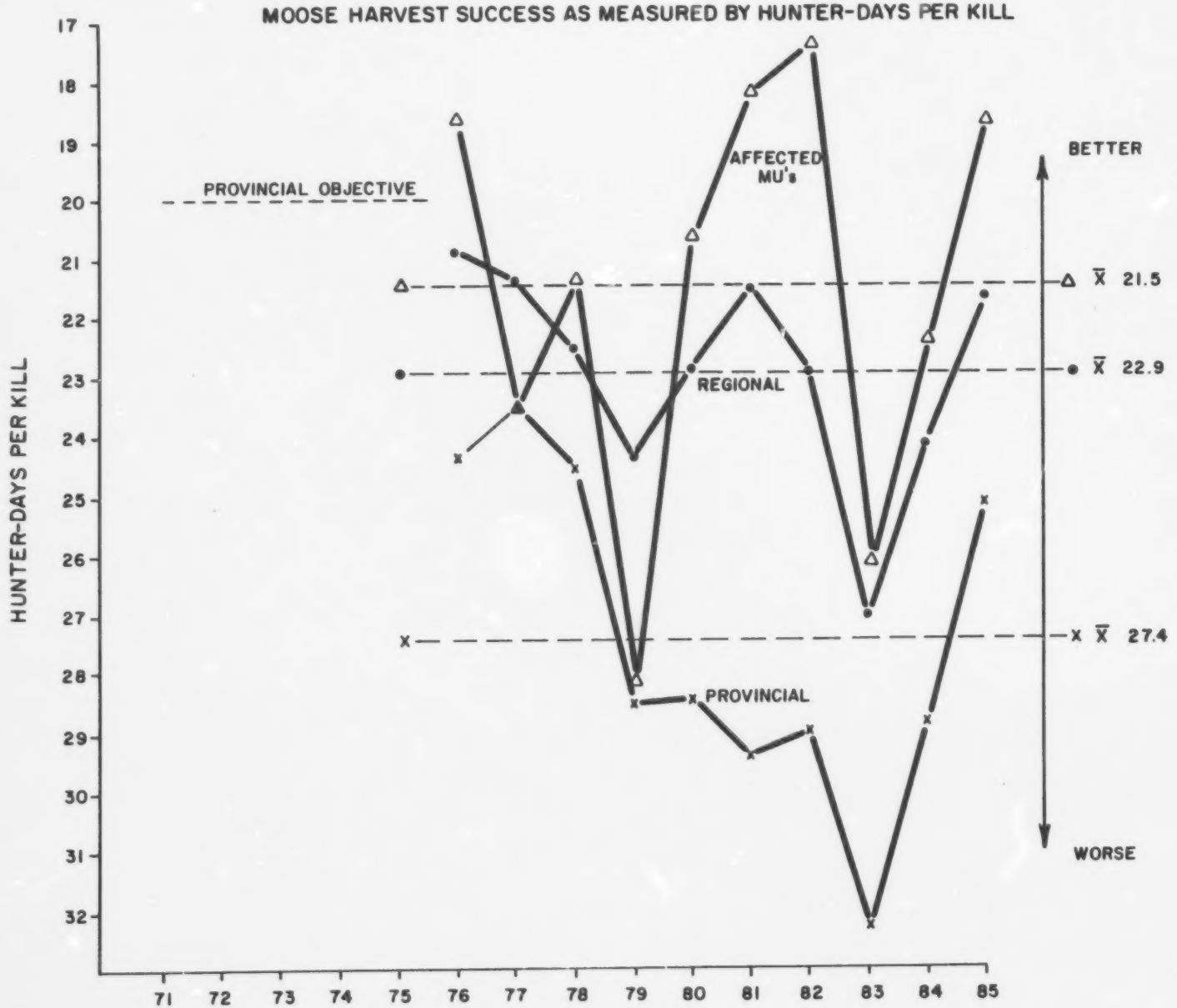
1985 has been considerably below that objective (Fig. 9-3); with an average of 27.4 days per kill and a range from 23.5 in 1977 to 32.3 in 1983. Regional success has been closer to the objective with an average of 22.9 days per harvest and a range from 20.9 in 1976 to 27.0 in 1983. In every year regional success was higher than provincial. The MUs impacted by the Williston Reservoir provided better success with this measure than did the rest of the region. The average was 21.5 days to produce a harvest, with a high of 17.4 days per kill in 1982 and a low of 28.2 days in 1979. In four of the 10 years, moose harvest success in the affected MUs has exceeded the provincial objective.

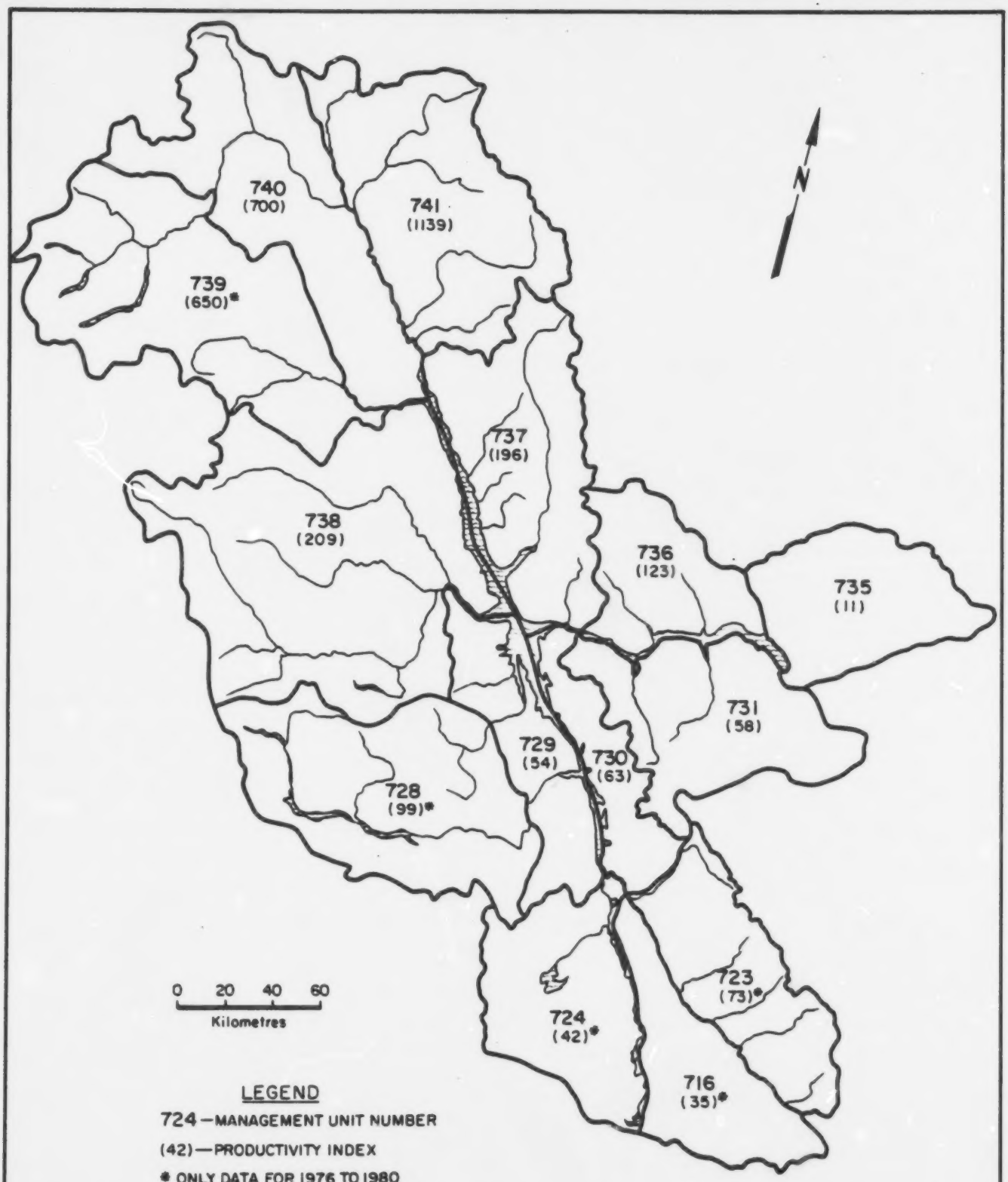
The MUs adjacent to the Peace Reach (731, 735 and 736) are prime range for moose. Both statistics for success are well above the values for provincial, regional or affected area average. In the worst of 10 years (1983) the hunter-days per harvest ratio barely dropped below the provincial objective. Moose hunting success in these units is among the best in B. C.

A productivity index which reflects habitat suitability, moose population, hunter accessibility and area (ha) was calculated for each MU in the vicinity (Fig. 9-4). The total area of each MU was divided by the average harvest per year to yield an estimate of the area required to produce one bagged moose. MU 735, the most productive was over 3 times as productive as the next highest, MU 716. The average harvest production for MU 735 was one moose per annum per 10.5 km^2. MU 716 produced one moose per 35 km^2 and values ranged down to MU 741, which only produced one moose per 1139 km^2.

Figure 9-3

MOOSE HARVEST SUCCESS AS MEASURED BY HUNTER-DAYS PER KILL





B.C. HYDRO

Figure 9-4

MANAGEMENT UNIT PRODUCTIVITY INDEX (AREA REQUIRED PER MOOSE HARVEST) FOR PERIOD 1976 TO 1985

9.2 IMPACT ASSESSMENT

For each specific location described by Bonar (1975), the potential for incremental wildlife impact (Appendix B) due to raising the water level 1.5 m has been assessed using 1:50 000 topographic maps, photographs, and communication with staff of the Wildlife Branch. Nine locations with high wildlife values and apparently low-lying habitat have been identified (Appendix B) as having a high potential for extensive loss.

These locations (Table 9-1) would be addressed in detailed studies should the reservoir raising project continue. For the purposes of this study total clearing of the flooded shoreline has been assumed. Sloughing of habitat would undoubtedly occur but this assessment has had to ignore quantification of its impact because of the lack of data. Shoreline instability in the Peace Reach could affect habitat availability especially for elk, Stone's sheep and mule deer (F. Harper, pers. comm.).

Moose populations are generally considered stable in the Williston Basin (ELUC Secretariat 1980) although actual population estimates are few. Even with the sparcity of population data the upper limit of impact can be approximated by examining assumptions. Hydro has estimated that about 6650 ha of shoreline would be flooded by raising the reservoir 1.5 m. The average moose density in the Peace region as estimated by the regional biologist is 0.6 moose/ km^2 (Ministry of Environment 1981, p. 4). The product of these two estimates gives an estimate of 40 moose to be displaced or lost due to raising. If one assumes the land flooded is 50 percent better than average land, the estimated displacement or loss would be 60 moose.

At the opposite extreme, a process of controlled photogrammetric interpretation plus extrapolation (see Forestry Section) has estimated the areas affected by flooding at 15 000 ha. This estimate would

Table 9-1

Locations Having Potential for Extensive Wildlife Losses

Location	General Wildlife Value
Pack River above Tudyah Lake	- Use by beaver, muskrat, mink and otter extensive - Ducks, geese and other waterfowl are frequent - More than three pairs of bald eagles and two pairs of osprey - Moose use area entire year, vegetation heavily used - Important moose calving area
Blackwater Swamp	- Excellent moose wintering area - Moose calving and rutting ground - Caribou use north
Bob Fry Creek	- Important to wintering moose - Some use by caribou in winter
Ingenika Arm to Swannell River	- Moose winter throughout *- Elk as well
Shovel Creek	- Fairly good moose range all year
Ospika River	- Numerous mineral licks used by alpine species
Ospika Arm	- Two mineral licks for moose and caribou
Parsnip River	- Extremely important wintering area for moose - Rutting and calving area - Considerable activity by waterfowl and aquatic furbearers *- Caribou in lower Parsnip and Pine Flats
North shore of Peace Reach	- Class 1 wintering range; flood risk low but sloughing risk high

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* Comments by K. Child. (Pers. comm.).

convert to a moose displacement or loss of 90, expanded to 135 for the "better-than-average" assumption.

Carrying capacity utilizes a system to estimate the maximum possible number of animals an area of land can produce assuming all factors are optimized for animal production. For practical purposes it is unlikely that these conditions would exist for the total reservoir area. However, for comparative purposes these conditions have been assumed. The upper limit of loss based on capability can be similarly calculated. Assuming an average capability rating of 3W which the Wildlife Branch rates as year- round capacity for 1.6 to 3.0 moose/km^2 (Demarchi et al. 1983) the minimum displacement or loss capacity would be between 105 and 198 and at the upper limit of land flooding the capability lost would be for 240 to 450 moose.

Eight guiding territories border on the existing reservoir, six of these are currently (1986) being utilized. Most of their operations are centred upon remote upland areas (ELUC Secretariat 1980) where the alpine and subalpine species of big game are the main attraction. Since the life histories of these species interact with reservoir shoreline on a limited basis, no significant impact is expected. Moose are frequently taken by guided hunters as a secondary species in this area but any population reduction brought about by reservoir raising would be passed on as a loss to these hunters.

Bonar (1975) interviewed several trappers or had them complete questionnaires from which he concluded that the trappers along the newly formed reservoir "generally concentrate their efforts in areas away from the reservoir shoreline". This observation may still be true because the highly variable reservoir level will have hindered the establishment of stable populations of aquatic and semi-aquatic furbearer species but would require verification.

The loss in game harvest caused by reservoir raising would not appear to be substantial. At the maximum calculated loss of capability for 450 moose and a harvest rate of 10 percent (Fish and Wildlife Branch 1979), the decrease in sustained yield would be 45. Using loss based on the average density, the sustained yield would decline to 10 for an area currently producing an average sustained harvest of 568 moose.

The Wildlife Branch has indicated as a first step in settling for losses caused by the orginal Williston project they would require an inventory program of $412,000 for biophysical mapping plus $1.4 million over 5 years to census animals in the remnant habitat (Ministry of Environment 1983).

SECTION 10.0 - FURTHER STUDIES

The overview assignment has identified data deficiencies for all disciplines. The most serious impediment to assessing project impacts is the absence of reliable mapping. Reliable mapping is essential to determine the property and socio-economic effects, forestry resource losses, clearing costs and others.

10.1 SOCIO-ECONOMICS

1. Undertake detailed socio-economic studies to further define the preliminary impacts and identify any additional impacts.

   Of particular importance would be clarifying the nature of the employment and economic impacts in terms of direct project employment, clearing-related employment, current and future forest industry employment.

   As part of these studies, consultation with government, industry, Indian Bands, interest groups and the public should occur.

2. Define the potential effects of flooding on Indian Bands inhabitating the reservoir shores. This would likely involve addressing preceived unsettled issues from the original Williston project.

   A process should be developed to include all parties such as B. C. Hydro, the Indian Bands, Department of Indian and Northern Affairs. As provincially managed resources such as fish, wildlife, forestry and land use could be affected, some government agencies should participate in these discussions. Opportunities

should be made available to the Bands to prepare their own proposals for solutions.

As a first step, priority should be given to finalizing negotiations with the Ingenika Band regarding a new Reserve. Properties Division is currently involved in this.

10.2 FORESTRY

The objective is to collect current data for the forest resources and infrastructure in this area. These data would be assessed to determine the effects of the incremental raising of Williston Lake and to propose clearing programs and determine their attendant costs.

1. Determine the resources to be affected and the impacts as a result of raising the reservoir.

    a. quantify and valuate the standing crop that would be flooded and the area of forest land taken out of production;

    b. determine the reduction in the Allowable Annual Cut for the Mackenzie Timber Supply Area;

    c. quantify the effect on the local economy of the change in timber supply;

    d. calculate the foregone stumpage due to the project; and

    e. identify compensation for unavoidable impacts.

2. Determine the effects on the logging industry infrastructure:

    a. inventory the existing facilities and planned additions;

b. evaluate the cost of protecting or replacing affected structures;

c. evaluate the potential additional transportation costs as a result of the reservoir raising; and

d. identify compensation for unavoidable impacts.

3. Develop a range of clearing standards, the attendant costs and schedule (time and extent) for the affected areas. Review the allocation of clearing contracts.

A new computer assisted inventory system employed by the Ministry of Forests and Lands may provide the opportunity to reduce the cost of the inventory activity.

10.3 HERITAGE

An archaeological survey would determine the extent of impacts on heritage resources and be the basis for preparation of a heritage impact assessment. The object of the archaeological survey would be to determine the extent and nature of archaeological remains which would be impacted by the raising of the reservoir.

The reservoir shoreline would be surveyed including excavating shallow test pits at potential cultural activity locations.

10.4 RECREATION

A study of the recreation capability of Williston Reservoir, with and without the proposed raising, would be undertaken. Water-oriented recreation and shoreline features would be highlighted in this review.

Data regarding the volume, distribution and activities of the recreation users of Williston Lake has never been collected on a comprehensive or continuing basis. To ensure an accurate data base for project evaluation, a comprehensive user study has been included. The recreation study would compensation and mitigation proposals designed to offset any residual negative impacts of the raising project on recreation resources. Estimated costs for these recreation proposals and consideration for phasing would also be addressed.

10.5 FISHERIES

The objective of fisheries studies would be to obtain current inventory data of the lake and its tributaries.

An assessment of potential impacts resulting from a raising of the reservoir would be conducted on the basis of baseline inventory data collected. Mitigation/compensation proposals would be develcped as appropriate.

(a) Limnology and Water Quality

Data on a number of physical/chemical parameters would be collected at various locations in each reach. Such information is important in evaluating background environmental conditions and fish habitat. Study activities would include:

1. Collect depth profile data on dissolved oxygen, temperature, conductivity, turbidity, depth of light penetration and other pertinent data at a number of sites in each reach including locations at or near gill net sets.

2. Gather information on the concentration of nutrients (phosphorous and nitrogen compounds) and metals particularly

mercury with depth from at least one location in each reach (deepest site).

3. Conduct a series of depth-sounding transects to provide information on basin morphology and for use in establishing gill net sites as well as background conditions in the reservoir.

4. Evaluate the impacts of a 1.5 m raising on limnological and other physical/chemical characteristics of the reservoir. Determine compensation measures as appropriate.

(b) Reservoir Studies

The main purpose of this work would be to determine the presence/absence of various fish types and relative species composition. These sites would be sampled in each reach with each netting location comprised of three different gill net sets. Nets would be set at different depths in each of the three locations such that the majority of habitat types would be sampled. Study activities would include:

1. Conduct depth profile transects at selected areas in each reach to select the best location for gill netting.

2. Set nets for approximately 24 hours. Each gill net set or "gang" would be comprised of five mesh sizes ranging from about 38 mm to 127 mm.

3. Collect data on fish size, sex and age. Scales and otoliths would be collected for age analysis.

4. Sample muscle tissue of selected sportfish species for mercury content analysis.

5. Assess fish species composition as well as growth and age characteristics. Compare species composition among the three reaches.

6. Evaluate the impacts of a 1.5 m raising on reservoir fish populations and develop compensation measures accordingly.

(c) Tributary Studies

Five to seven tributaries from each reach would be evaluated. Tributaries selected would represent the range of tributary characteristics encountered in each reach. Data from this program would be used in extrapolating the nature of the fisheries resources in unsampled tributaries. Study costs would be impractically high to carry out a more detailed evaluation.

Specifics of the tributary studies would include:

1. Conduct a helicopter flight to select tributaries for more detailed evaluation.

2. Determine species presence/absence by electroshocking, beach seining and other methods as appropriate to the particular tributary.

3. Evaluate abundancies and densities of resident fish populations.

4. Carry out a "reach card analysis" on sampled portions of the tributaries. Data recorded would include gradient profiles, substrate characteristics, flow patterns, observations of general habitat and limits of migration and spawning for fish.

5. Collect scale samples and otoliths for aging fish.

6. Evaluate importance of selected tributaries to fish production in the reservoir.

7. Determine the potential impacts of raising Williston Reservoir 1.5 m on fisheries resources in tributaries.

10.6 WILDLIFE

The proposed studies would quantify the impacts on wildlife in the Williston Lake area with special emphasis on the nine areas where the greatest potential for impact exists. The studies would quantify the areal effects, the wildlife capability of the areas affected, and the current status of use of the area.

SECTION 11.0 - CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

The assessment of the data available has not identified any socio-economic or environmental impacts that would justify not proceeding with the project. It is not expected that further investigations would reveal any issues significant enough to impede the project.

The costs of pre-raising clearing and post-raising cleanup of the reservoir are $14,930,000 for 6650 ha affected to $31,160,000 for 15 000 ha affected.

Proceeding with the raising project will likely prompt demands that outstanding issues from the original project be dealt with. These could include fish and wildlife mitigation and compensation, land negotiations with the Ingenika Band and others.

It is anticipated that complete clearing of the flooded area will be expected. The clearing of this band would leave unsightly "standing deads" and other presently existing debris that Hydro may be required to remove.

The two major benefits of the project would be the long-term energy benefits and the employment created during construction, primarily from the clearing program.

11.2 RECOMMENDATIONS

New air photos and mapping be obtained of the entire reservoir area to enable an accurate estimate to be made of the area that would be inundated by the raising. Based on this area, the cost estimates in this report would be updated and the project economics reassessed.

If the results of the above recommendation indicate a viable project then detailed feasibility/preliminary design studies should be initiated.

BIBLIOGRAPHY

General

B. C. Hydro. 1987. Williston Reservoir Raising Overview Study - Project Report. Hydroelectric Engineering Division.

B. C. Hydro. 1987. Preliminary Study of Properties Costs Associated with the Proposed Raising of the Williston Reservoir to 2210 feet. Properties Division.

Socio-Economic

Boivin, J. 1982. Carrier-Sekani Comprehensive Claim Analysis. Office of Native Claims.

District of Mackenzie. 1983. Community Profile. Research Department.

ELUC Secretariat. 1980. A Resource Management Strategy for the Williston Basin. Draft Manuscript. July 1980.

Government of Canada, Province of British Columbia. 1982. The Peace River Alaska Highway Tourism Region. A Canada-B. C. Travel Industry Development Subsidiary Agreement. Regional Tourism Study.

Kaska Dena Council. 1982. Submission of the Kaska Dena Council for Recognition of Their Comprehensive Claim to Lands in Northern British Columbia.

Melville, J. B. 1979. Indian Bands in British Columbia. A Cross Referenced Index. B. C. Hydro.

Peace Liard Employment Development Association. 1985. Peace Liard Economic Profile.

Veit, S. 1978. Report on Environmental Studies for the McGregor River Diversion Project. Prepared for B. C. Hydro by Reid, Crowther and Partners Limited.

West Coast Information and Research Cooperative. 1985. McLeod Lake Development Package. Prepared for Office of Native Claims and McLeod Lake Band.

Forestry

Holland, S. S. 1964. Landforms of British Columbia: A Physiographic Outline. B. C. Department of Mines and Petroleum Resources, Victoria. 138 p.

Krajina, V. J. 1973. Ecology of Western North America. University of British Columbia. 147 p.

Meidinger, D., T. Lewis and R. Kowall. 1986. Biogeoclimatic Zones and Subzones on the Northern Portion of the Mackenzie Timber Supply Area, British Columbia. Northern Fire Ecology Project. B. C. Ministry of Forests.

Ministry of Forests. 1980. Forest and Range Resource Analysis. Technical Report Volume 1.

Heritage

Albright, S. L. 1982. Review of the Kaska Dena Land Claim Submission. Submitted to the Office of Native Claims, Vancouver Office Department of Indian Affairs and Northern Development.

Albright, S. L. 1984. Tahtlan Ethnoarchaeology. Department of Archaeology; Simon Fraser University.

Boivan, J. B. 1982. Carrier-Sekani Comprehensive Claim Analysis. Indian and Northern Affairs, Canada.

Brody, H. 1981. Maps and Dreams. Douglas and McIntyre Ltd., Vancouver, B. C.

Cassidy, S. 1976. Preliminary Report on the Archaeological Potential of those Areas Affected by the McGregor River Diversion Project. From a report submitted to The Archaeological Sites Advisory Board Province of British Columbia.

Duff, W. 1964. The Indian History of British Columbia, Anthropology in British Columbia, Memoir No. 5. Provincial Museum of British Columbia.

Fladmark, K. R. 1983. Times and Places: Environmental Correlates of Mid-to-Late Wisconsinian Human Population Expansion in North America; Early Man in the New World. Edited by Richard Shutler Jr. Sage Publications Inc. Beverly Hills, California.

Jenness, O. 1937. The Sekani Indians of British Columbia. Department of Mines and Resources. Bulletin No. 84. Anthropology Series No. 20, Ottawa.

McGhee, Robert. 1963. An Archaeological Survey in the Area of the Portage Mountain Dam Reservoir. University of British Columbia.

Ministry of Provincial Secretary and Government Services. 1981. Blue Paper No. 7. Heritage Considerations. Province of B. C.

Mitchell, D. H., and T. Loy. 1981. An Overview of Liard River Valley Heritage Resources. A report submitted to B. C. Hydro. University of Victoria.

Spurling, B., F. Finlay and K. R. Fladmark. 1976. Report on the Peace River Archaeological Survey and Salvage Project. 1976 Field Season. Department of Archaeology, Simon Fraser University.

Vanstone, J. W. 1974. Athapaskan Adaptations. Aldine Publishing Company, Chicago, Illinois.

Recreation

Coombes, D. M. 1977. Outdoor Recreational Potential in the Williston Study Map Area. Prepared for Resource Analysis Branch, Ministry of the Environment.

D.P.A. Consulting Limited. 1981. Peace River - Site C Recreation Survey. Prepared by B. C. Hydro.

ELUC Secretariat. 1982. A Resource Management Strategy for the Williston Basin. 67 pp. Draft. March 1982.

MacDonald, D. and J. Thomas. 1981. The Recreational Resources of Williston Reservoir. Prepared for Reservoir Land Management Department, B. C. Hydro by Life-Space Designs Ltd. and John Thomas and Associates.

Marshall, Macklin Monaghan Limited. 1982. The Peace River - Alaska Highway Tourism Region. Prepared by Ministry of Industry and Small Business Development and Ministry of Tourism.

Parfitt, R. 1980. The Feasibility of a Marina on Williston Lake. Prepared for the District of Hudson's Hope.

Fisheries

B. C. Research. 1974. Limnological Studies on Williston Lake During Fall 1974. November 1974. 9 p.

B. C. Research. 1977. Limnology of Arrow, McNaughton, Upper Campbell and Williston Lakes. 102 p.

B. C. Research. 1975a. Limnological Studies of Williston lake During Summer and Fall, 1975. 63 p.

B. C. Research. 1975b. Limnological Studies on Williston Lake During Ice-Cover. 3 p.

Barrett, D. T. and T. G. Halsey. 1985. Fisheries Resources and Fisheries Potential of Williston Reservoir and its Tributary Streams. Volume I. Fisheries Resources and Fisheries Potential of Williston Reservoir. Fisheries Technical Circular No. 68. Ministry of Environment, B. C. 40 p.

Bodaly, R. A., R. E. Hecky and R.J.P. Fudge. 1984. Increases in Fish Mercury Levels in Lakes Flooded by the Churchill River Diversion, Northern Manitoba. Can. J. Fish. Aq. Sciences 41:682-691.

Bruce, P. G. and P. J. Starr. 1985. Fisheries Resources and Fisheries Potential of Williston Reservoir and its Tributary Streams. Volume II. Fisheries Resources Potential of Williston Lake Tributaries. A Preliminary Overview. Fisheries Technical Circular No. 69. Ministry of Environment, B. C. 101 p.

Bruce, W. J., and K. D. Spencer 1979. Mercury Levels in Labrador Fish, 1977-78. Can. Ind. Rep. Fish Aquat. Sci III: IV + 12p.

Cox, J. A., J. Carnahan, J. Di Nunzio, J. McCoy and J. Meister. 1979. Source of Mercury in Fish in New Impoundments. Bull. Environ. Contam. Toxicol. 23:799-783.

D'Itu, P. A. and F. M. D'Itu. 1978. Mercury Contamination: A Human Tragedy. Environmental Management 2(1):3-16.

Health and Welfare Canada. 1978 - 1981. Mercury Surveillance Report: North East Zone Medical Services. Confidential Medical Data to be Cited with Caution and Limited Distribution.

Johnels, A. G., T. Westermark, W. Berg, P. I. Persson and B. Sjostrand 1967. Pike and some other aquatic organisms in Sweden as indicators or mercury containment in the environment. Oikos 18: 323-33.

Jones, M. L., G. L. Cunningham, D. R. Marmorek, P. M. Stokes, C. Wren, D. Degraff 1986. Mercury Release in Hydroelectric Reservoirs. Report for the Canadian Electrical Association. CEA No. 185 G 399.

Koirtyohann, S. R., R. Meers and L. K. Graham 1974. Mercury levels in fish from some Missouri Lakes with and without known mercury pollution. Eviron. Res. 8:1-11.

McPhail, J. D. and C. C. Lindsey. 1970. Freshwater Fishes of Northwestern Canada and Alaska. Fish Res. Bd. Canada Bull. No. 173.

Smith, H. A. 1986. Data from Limnological Studies Carried Out on Williston Reservoir in 1981 and 1982. Mimeo.

Waite, D. T., G. W. Dunn and R. J. Stedwill 1980. Mercury in Cookson Reservoir Sask. Environ. Wat. Pollut. Control Branch. WPC23:19 p.

Westoo, G. 1986. Determination of Methylmercury Compounds in Foodstuffs. I. Methylmercury Compounds in Fish, Identification and Determination. Acta. Chemc. Scand. 20:2131-2137.

Withler, I. L. 1959. Fisheries Problems Associated with Development of the Peace River and its Upper Tributaries for Hydroelectric Purposes. Fish Management Report No. 31. B. C. Fish and Wildlife Branch. 120 p.

Wobeser, G., N. O. Nielsen, R. H. Dunlop, and F. M. Cetton 1970. Mercury concentrations in tissue of fish from the Saskatchewan River. J. Fish Res. Board Canada 27: 830-835.

Wildlife

Bonar, R. L. 1975. Wildlife Resources and Habitat in the Williston Reservoir Area of North Central British Columbia. B. C. Fish and Wildlife Branch, Prince George. Draft.

Canada Land Inventory. 1970a. Land Capability for Wildlife-Ungulates. Department of Regional Economic Expansion. Maps

Canada Land Inventory. 1970b. Land Capability for Wildlife-Waterfowl. Department of Regional Economic Expansion. Maps.

Demarchi, D. A. B. Fuhr, B. A. Pendergast and A. C. Stewart. 1983. Wildlife Capability Classification for British Columbia: An Ecological (Biophysical) Approach for Ungulates. MOE Manual 4, Victoria, B. C. 56 pp.

ELUC Secretariat. 1982. A Resource Management Strategy for the Williston Basin. 67 pp. Draft. March 1982.

Fish and Wildlife Branch. 1976 to 1985. Hunter Sample. Statistical Volumes and Computer Print-outs.

Fish and Wildlife Branch. 1979. Proposed Wildlife Management Plan for British Columbia. Ministry of Environment. 89 pp.

Fish and Wildlife Branch. 1981. Preliminary Elk Management Plan for British Columbia Ministry of Environment. 29 pp.

Fish and Wildlife Branch. 1985. Wild Fur Harvest Summary Report. Ministry of Environment. Computer print-out. 23 August 1985.

Ministry of Environment. 1983. Finlay-Omenica Strategic Environmental Plan. Technical Report. Planning and Assessment Branch and Omineca-Peace Region.

APPENDIX A
PERSONAL COMMUNICATION

This overview study has had to rely on literature sources and personal contact with individuals knowledgeable about the Williston area. We would therefore like to gratefully acknowledge the cooperation and time given by the numerous individuals who were contacted by telephone, scheduled meetings, or letters. The following people provided special assistance.

If we omitted anyone please accept our apologies.

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APPENDIX B

WILDLIFE VALUES EXTRACTED FROM BONAR (1975)

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Pack River (above Tudyah Lake)	- Beaver, muskrat, mink and otter use quite extensive - Ducks, geese and other waterfowl frequent - More than 3 pairs bald eagles, 2 pairs osprey - Moose use area entire year, vegetation heavily utilized - Important moose calving area	- May flood extensively - Needs detailed work	5
Lignite and Scovil Creeks	- Small potholes reasonably important to waterfowl - Some evidence of moose winter range - Caribou utilize area during certain periods	- Probable loss - Habitat reduction	4
Didche and Scovil Creeks	- Important to moose entire year - Calving and rut area - Beavers particularly active along reservoir	- Above - Habitat reduction	1 4
Modeste Lake	- Important waterfowl nesting area - Populations of aquatic mammals high - Good moose habitat	- Well above	0
Tsedeka Creek	- Little present value of wildlife habitat	- Above	1
Tsedeitla Lake	- Good areas for moose, aquatic mammals and waterfowl - Particularly high moose population	- Well above	0
Tsedeka Creek to Reservoir	- Excellent moose winter range - Beaver particularly active on shoreline	- Habitat reduction	4
Upper Dastaiga Creek	- Potholes and swamps excellent habitat for aquatic mammals and waterfowl - Sizeable population of moose for entire year	- Above	1

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Nation River	- Moose utilize swamps and potholes - Waterfowl populations good - Bluffs provide winter forage for deer	- Probable reduction	4
Dastaiga Creek to Nation River	- Flat along shoreline poor wildlife capability	- Low losses	3
Blackwater Creek	- Excellent moose winter range	- Above	1
Burden Lake	- Important to waterfowl and beaver - Moose and deer utilize most of year	- May link to reservoir - Probably not affected	4 2
Blackwater Logging Area	- Moose populations affected by logging and access - Browse species for moose on increase	- Some habitat loss	3
Blackwater Swamp	- Excellent moose wintering area although use all year - Moose calving and rutting ground - Caribou use north end in winter	- May flood extensively - Needs detailed work	5
Manson River	- Moose utilize river flat all year - Mink and otter plentiful; some beaver - Canada geese nest along river with other waterfowl - Osprey and bald eagles nest nearby - Nearby benches low values for wildlife	- Some habitat reduction - Probably not affected - Probably not affected - Probably not affected - Probably not affected	3 2 2 2 2
Manson Point	- Some good moose winter range - Waterfowl nesting in shallow ponds	- Above	1
Manson Arm Shoreline	- Generally low wildlife values - Swampy area excellent wintering for moose and caribou	- Some habitat reduction - Above	3 1
Curve Lake	- Excellent moose habitat all year, especially calving and rutting	- Above	1
Eklund Creek	- Winter range for moose and caribou	- Above	1
Shoal Lakes	- Low wildlife value; some moose and waterfowl	- Above	1

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Fries Creek	- Excellent aquatic mammal habitat	- Slight habitat reduction	3
Strandberg Creek	- Low in wildlife values - Upper sections important to moose, waterfowl and aquatic mammals - Wintering area for moose	- Some habitat reduction - Above	3 1
Wolverine Range	- Moderate goat numbers - Excellent caribou range - Moose use during summer	- Well above	0 0 0
Omineca and Osilinka Rivers	- High in wildlife values - Moose use area year round - Canada geese nest along the river - Aquatic mammals (mink, otter, beaver) abundant	- Small habitat reduction	3
Mesilinka River	- Open bluffs used by moose and deer - River flat good habitat for moose, waterfowl and aquatic mammals	- Above - Small habitat reduction	1 3
Northside Omineca Arm	- Medium moose winter range - Swampy area important to wintering moose	- Small habitat reduction - Above	3 1
Potholes South of Omineca Arm	- Good moose habitat - Important to waterfowl and aquatic mammals	- Above	1
Omineca Burn	- Excellent moose wintering range	- Unknown	3
Raspberry Harbour	- Very low wildlife values	- Some habitat reduction	3
Bob Fry Creek	- Important to wintering moose - Some use by caribou in winter	- May flood extensively - Needs detailed work	5
Chunamon Creek	- Low wildlife values	- Probably not affected	2
Teare Creek to Pete Toy Creek	- Low wildlife values - Alpine areas excellent caribou habitat	- Probably not affected - Well above	2 0

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Mica Creek to Lorimer Channel	- Moderate moose wintering habitat - A burn is good moose habitat all year	- Probably not affected - Above	2 1
Ole Creek to Stromquist Point	- Large burn is best available wintering area for moose on eastern Butler range	- Probably not affected	2
Mica Peak and Mt. Henri	- Some mountain goat and stone sheep - Caribou fairly abundant	- Well above	0
Factor Ross Creek to Frank Creek	- Low wildlife values - Potential caribou habitat but not heavily used	- Probably not affected	2
Ingenika Arm - Swannell River	- Moose winter throughout - 1970 burn is excellent moose winter habitat	- Possible extensive flooding - Above	5 1
Isola Creek and Lakes	- Moderately important to moose	- Probably not affected	2
Deserter's Canyon	- Low to moderate moose habitat - Goat and caribou use area to cross Rocky Mountain Trench	- Above - Above	1 1
Ed Bird Lake	- Excellent waterfowl and summer ungulate range	- Small habitat loss possible	3
Estella Lakes and Tsaydizkun Swamp	- Prime caribou winter range	- Probably not affected	2
Finlay River	- Of highest values for wintering moose, aquatic mammals and Canada geese	- Above	1
Taper Mtn. and Pesika Mtn.	- Excellent habitat for mountain goat - Slightly less than excellent for caribou	- Well above	0
Deserter's Creek	- Excellent area for moose during entire year	- Above	1

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Rubyred Creek	- Excellent area for moose during entire year	- Small habitat loss	3
Snowtop Peak and Deception Cone	- Excellent goat country - Good caribou populations - Moose use alpine areas during summer	- Well above	0
Deception Cone Lowlands	- Fairly good moose wintering areas near reservoir	- Possible reduction	4
Police Creek	- Good winter range for moose - Caribou utilize higher elevation forests	- Probable reduction - Above	4 1
Chowika Creek	- Moderate to low wildlife values	- Probable reduction	4
Chowika Mountain	- Particularly large numbers of mountain goat - Moderate numbers of caribou	- Well above	0
Shovel Creek	- Fairly good moose range all year	- Possible extensive loss	5
Mt. Grahame	- Both goat and caribou use the area - Good winter range for moose	- Well above - Above	0 1
Davis River	- Benches are good winter range for moose	- Above	1
Bruin Creek to Collins Creek	- Poor value for moose	- Probable reduction	4
Collins Creek to Lafferty Creek	- Moderately good moose winter range	- Probable reduction	4
Lafferty Creek	- Moderate to low wildlife areas	- Small habitat loss	3
Tobin Lake Inlet	- Excellent value for moose entire year	- Well above	0
Mt. Moodie	- Low to moderate wintering values - Excellent moose summer range	- Well above	0

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Ospika Arm	- Outwash south of Tobin Lake has moderate value as a moose wintering area	- Small habitat loss	3
	- Two mineral licks for moose and caribou	- Possible loss Needs detailed work	5
	- Burn north of reservoir and up Ospika River is number one moose winter range	- Probably not affected	
	- South side of Arm excellent moose winter range	- Small habitat loss	3
Ospika River	- Prime wildlife habitat for moose, waterfowl and furbearers	- Probable reduction	4
	- Numerous mineral licks used by alpine species	- Possible extensive loss - Needs detailed work	5
Point South of Ospika Arm	- Excellent moose and aquatic mammal habitat - Small elk herd in the area	- Probable reduction	4
Bevel Creek to Lost Canyon Creek	- Moderately good wintering areas for moose	- Probably not affected	2
Colin Creek to Weston Creek	- Low values for wildlife, heavy snowfall	- Probable reduction	4
Weston Creek	- Important to wintering moose	- Small habitat loss	3
Scott Creek	- Excellent moose winter habitat but low use	- Small habitat loss	3
Six Mile Creek	- Good moose habitat - Beaver and waterfowl abundant	- Small habitat loss	3
Cut Thumb Creek	- Good winter range for moose	- Small habitat loss	3
Dina and Heather Lakes	- Moderately useful to waterfowl - Low values to moose	- Probable reduction	4
Tony Creek to Tutu Creek	- Moderate to good calving, rut, summer and wintering range	- Probable reduction	4
Mugaha Creek	- Fairly good moose wintering area	- Small habitat loss	3

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Morfee Lakes	- Good moose wintering areas - Utilization limited by proximity of Mackenzie	- Probable reduction	4
Gagnon Creek	- Some swamps and potholes with moderate moose populations all year - Waterfowl and beaver use area extensively - Proximity to Mackenzie limiting	- Small habitat loss	3
Gataiga Creek	- Majority poor capability for moose - Swamps near reservoir heavily used - Used by moose, waterfowl and aquatic mammals	- Probable reduction	4
Mischinsinlika	- Useful to wintering moose - Beaver quite active in the area	- Small habitat loss	3
Pack - Tudyah - Parsnip Triangle	- Very limited capability for ungulates and waterfowl - Moose and caribou cross the area	- Above flooding	1
Chain of Lakes North of Tudyah	- Fairly good moose wintering habitat - Waterfowl quite abundant	- Probable reduction	4
Parsnip River	- Extremely important as wintering areas for moose, also rutting and calving area - Some usage by caribou - Considerable activity by waterfowl and aquatic furbearers	- Possible extensive loss - Needs detailed work	5
Lost Cabin Creek	- Moose not present in any numbers - Goat and caribou crossing flooded previously - Goat on ridge all year - Caribou present in summer	- Probably not affected - Well above flooding	2 0
Mt. Selwyn	- Excellent goat habitat - Caribou populations high on nearby ridges - 35 to 40 stone sheep from here to Mt. Crysdale	- Well above flooding	0
Hamlyn Creek	- Little moose use - Goat move through area	- Probably not affected	2

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Wedge Peak to Advance Mountain	- Excellent goat habitat all year	- Well above flooding	0
Bernard Creek	- Used by goat to some extent but generally low in wildlife value	- Above flooding	1
	- Moose utilize higher elevations in summer	- Well above flooding	0
Point/Clearwater/Ducette Creeks	- Good summer range for moose	- Probable reduction	4
Weasel Creek	- Excellent moose winter range on flat near mouth	- Above flooding	1
Nabesche River	- Excellent moose and deer winter range	- Probably not affected	2
Pardonet Creek	- Moderate winter range for moose	- Small winter loss	3
Schooler Creek	- Good habitat for moose and deer	- Probably not affected	2
Carbon Creek	- Good for moose and deer but snow depths high	- Probably not affected	2
Indian Head	- Useful as winter range for deer and moose	- Above flooding	1
Peace Bluffs	- Heavily used deer and moose summer range - Conflicts with cattle grazing	- Probably not affected	2
Aylard Creek	- Large burn provides high value moose and deer range	- Small habitat loss	3
Carbon Peak	- A few caribou and goat	- Well above flooding	0
Dunlevy Creek	- Excellent winter and summer range for deer, moose and elk	- Probable reduction	4
Butler Ridge	- Very good caribou habitat - Small band of stone sheep - Mineral licks used by moose	- Well above flooding	0

Location	General Wildlife Value	Potential Flooding Impact	Severity Rating
Stott to Table Creeks	- Fairly low value habitat - Moose and deer present in summer	- Probably not affected	2
Mt. Gething	- Small population of goats - Caribou use possible	- Well above flooding	0